Tools for the identification and description of competencies

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Open Universiteit Nederland

Heerlen, 2005

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Dit onderzoek werd uitgevoerd in het kader van het Interuniversitair Centrum voor Onderwijsonderzoek.

Druk	Datawyse Maastricht www.datawyse.nl
Uitgever	Open Universiteit Nederland Postbus 2960 6401 DL Heerlen www.ou.nl
Omslag	Vormgeving: Jeroen Berkhout Illustratie: © Angela Stoof, linosnede gebaseerd op rotstekeningen in Ilkley, Yorkshire

ISBN 90-358-2219-6

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PROEFSCHRIFT

Ter verkrijging van de graad van doctor aan de Open Universiteit Nederland
op gezag van de rector magnificus prof. dr. ir. Mulder

ten overstaan van een door het College voor promoties ingestelde commissie
in het openbaar te verdedigen op
vrijdag 4 maart 2005 te Heerlen om 16.00 uur precies

door

Angela Stoof

geboren op 21 februari 1974 te Rotterdam

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Voorwoord

Het Voorwoord van een proefschrift is het leukste gedeelte om te schrijven. Het wordt namelijk als laatste geschreven, wanneer alle andere delen van het proefschrift gereed zijn en de promovendus of promovenda met een diepe zucht achterover in de stoel kan zakken. Wat het schrijven van een Voorwoord ook leuk maakt, is dat het het enige deel van het proefschrift is dat niet aan regels gebonden is. De aankomende doctor mag hier in feite alles schrijven wat in zijn of haar hoofd opkomt, of dat nu een grote dankbaarheid jegens ontvangen steun is (daar gaat een Voorwoord meestal over), over de frustraties en moeilijke momenten die er zijn geweest (dat wordt toch wat minder vaak gerapporteerd), of over andere dingen. Daar komt nog bij dat het Voorwoord zeer waarschijnlijk het meest gelezen deel van het proefschrift zal zijn. Het is in het Nederlands en het is niet-wetenschappelijk, waardoor het voor iedereen leesbaar is. Bovendien voegt het Voorwoord iets persoonlijks toe aan het proefschrift: het zegt iets over "de mens naast de wetenschapper". Kortom, alle reden dus om een poging te wagen van een Voorwoord iets bijzonders te maken.

Ik wil mijn Voorwoord gebruiken om toch nog maar eens uit te leggen waar het onderzoek dat ik de afgelopen jaren gedaan heb over gaat. En dan niet op een wetenschappelijke manier, maar op mijn eigen manier. Hierbij maak ik gebruik van een aantal door mij zeer geliefde personages uit *Winnie-de-Poeh* en *Het Huis in het Poeh-Hoekje* van A.A. Milne, en van een manier van uitleggen die door Benjamin Hoff wordt gebruikt in *Tao van Poeh* en *Teh van Knorretje*.

Competenties in het Honderd-Bunders-Bos

Uil had alle dieren van het Honderd-Bunders-Bos bijeen geroepen voor een Zeer Gewichtige Zaak. Iedereen was er: Poeh, Knorretje, Tijgetje, Konijn en zijn hele familie, Kanga, Roe, en helemaal achteraan stond Iejoor. Allemaal waren ze reuze benieuwd naar wat Uil te vertellen had. Want als Uil zei dat het om een Gewichtige Zaak ging, dan ging het ook om een Gewichtige Zaak.
Uil opende de bijeenkomst: "Beste Allemaal. Ik, Uil, heb een Verkondiging ontvangen van Janneman Robinson." En Uil hield een papier omhoog zodat iedereen kon zien dat hij, Uil, inderdaad een Verkondiging ontvangen had. Helemaal bovenaan stond met grote letters:

RAPPORT
Van Janneman Robinson.

Uil ging verder: "In deze Verkondiging wordt een heel Gewichtige Zaak besproken. Het gaat namelijk over *Competenties*."
"Aha!" riep Konijn. "Daar weet ik alles van, van competities!" En voor iemand *boe* of *ba* kon zeggen was Konijn er al vandoor en rende zo hard hij kon langs de rand van het Bos. Even later rende er een gele vlek achter Konijn aan. Bij nader inzien bleek het Tijgetje te zijn, die met grote sprongen probeerde om Konijn in te halen.
"Ik wil ook mee! Ik wil ook mee!" gilde Roe en probeerde zich uit de draagzak van Kanga te wurmen.
Uil overzag de chaos en zei eerst tegen zichzelf: "Maak je niet druk. Maak je niet druk." Maar toen zwol Uil een beetje op, en nog meer, en nog meer, totdat hij er tenslotte uit zag als een ronde, gevederde voetbal. En nog even later stonden al zijn veren ook nog eens overeind, zó boos was Uil nu. En hij brulde heel hard: "STILTE!"
Daar kwamen Konijn en Tijgetje alweer terug. "Heb ik gewonnen?" vroeg Konijn nog, maar Uil keurde hem geen blik waardig.
"Goed", vervolgde Uil. "Een Gewichtige Zaak dus. Vandaag gaan we het daarom hebben over *onze* Competenties."

Het bleef een hele tijd stil.

Uil deed zijn snavel open en toen weer dicht, en nog een keer open en weer dicht.
Ineens klonk er een Vreemde Stem: "Wazziecollizies?" De Vreemde Stem was van Poeh, die net zijn mond vol had met een hapje van 't één of ander.
"Ja, wat zijn Competenties?" durfde nu ook Knorretje te vragen.
"Nou, je-weet-wel", zei Uil uit de hoogte. "Dat wat je altijd hebt."
"O ja", zei Knorretje, en hij kroop voor de zekerheid maar een beetje weg achter Poeh.
"Nou, dan zal ik maar gaan", zei Iejoor toen. "Want dat wat iedereen altijd heeft, heb ik vast en zeker niet."
Nu begon iedereen door elkaar heen te praten, behalve Poeh, die met zijn kop in een pot Honing zat. Uil sprong op en neer op zijn tak en zijn veren stonden nu werkelijk alle kanten op.
"STILTE!" brulde hij weer, en bijna viel hij van zijn tak af. Toen hij zijn evenwicht weer had gevonden, liet hij de Verkondiging nog maar eens zien.
"Kijk", zei hij, "hier staat het. Rekencompetentie: 7. Schrijf-competentie: 8. En helemaal onderaan: Tekencompetentie: 6."
"Ik kan niet rekenen", zei Knorretje.
"Ik ook niet!" piepte Roe, en ook de andere dieren schudden hun hoofd en keken een beetje moeilijk.
Uil probeerde zijn geduld te bewaren.

"Er zijn ook *andere* Competenties", legde hij uit. "Zoals een Gewichtige Zaak Bespreken", en hij keek trots rond vanaf zijn tak.
"En Heel Ver Springen?" vroeg Kanga toen.
"Lekker Graven in een Zacht Heuveltje", zei Konijn.
"Een Flipperdeflap vangen!" riep Knorretje.
En toen ging iedereen weer door elkaar heen praten, want ineens kon iedereen wel een Competentie bedenken. En net toen Tijgetje zijn Allerbeste Competentie wilde laten zien (waar hij om de één of andere reden Iejoor bij nodig had), rende Poeh ergens heen. En iedereen stopte met praten, want Poeh rende nooit.
"Kijk eens!" zei hij, en hij haalde een grote druipende honingraat uit een holle boom.
Knorretje knikte en zei: "Dat is wat ik noem een Competente Honingzoeker".
"Juist", zei Uil tevreden. "We zullen met Poeh beginnen." En hij pakte een papier en een pen, en schreef bovenaan het vel:

COMPETENTIES VAN POEH-BEER

En dit is het punt waar het onderzoek dat ik de afgelopen jaren gedaan heb begint. Tegenwoordig draait het onderwijs niet meer om kennis, vaardigheden en attituden, maar om competenties. Eén van de redenen hiervoor is dat men vindt dat kennis, vaardigheden en attituden niet los van elkaar staan maar één geheel vormen. Het geheel van kennis, vaardigheden en attituden dat nodig is om bijvoorbeeld een bepaalde taak uit te voeren wordt een competentie genoemd. Hierbij moet wel worden opgemerkt dat dit slechts één van de opvattingen over competentie is. Er zijn heel veel verschillende definities van competentie en dat maakt het er niet overzichtelijker op.

Een andere reden waarom onderwijsinstellingen competenties centraal stellen is om het onderwijs beter aan te laten sluiten bij het werkveld en de samenleving in zijn algemeen. Vooral werksituaties worden steeds complexer en veranderen snel. Door de centrale rol van de computer is er steeds meer informatie voorhanden, verlopen allerlei werkprocessen veel sneller en geavanceerder en is het mogelijk om op grote schaal contacten te onderhouden en samen te werken met andere mensen. De term competentie biedt aanknopingspunten om na te denken over al deze veranderingen en de gevolgen daarvan voor het onderwijs.

De eerste stap in het ontwikkelen van competentiegericht onderwijs is het in kaart brengen van de competenties die studenten tijdens een bepaalde opleiding moeten verwerven. Om een voorbeeld te geven: een opleiding Psychologie moet in kaart brengen welke competenties een psycholoog nodig heeft om zijn of haar vak goed te kunnen uitoefenen. Dit lijkt heel eenvoudig, maar niets is minder waar. Het is erg moeilijk om competenties te benoemen, onder andere omdat er geen procedures zijn om competenties op een goede en betrouwbare manier in kaart te brengen. Dit is natuurlijk een groot probleem, omdat competenties de basis voor een competentiegerichte opleiding vormen.

> Uil blies de inkt op het papier droog en keek Poeh vorsend aan.
> “Zo, vertel maar eens”, zei hij.
> Poeh stond net op het punt om een likje van de honingraat te nemen.
> “Moet ik een Verhaal vertellen?” vroeg hij toen, en nam toen maar snel een lik voor Uil nog meer vragen kon stellen.
> Uil schudde zijn wijze bol en slaakte een diepe zucht.
> Knorretje trok aan Poeh’s poot. “Ik denk, Poeh, dat Uil bedoelt hoe je Honing vindt.”
> “Juist”, zei Uil, en hij zette zijn pen alvast weer op het papier.
> “Tsja”, zei Poeh, en probeerde eruit te zien alsof hij heel hard aan het nadenken was.
> “Tsja”, zei hij toen weer en bekeek zijn honingraat nog maar eens.

Het is dus niet eenvoudig om te bepalen welke competenties nodig zijn om een bepaalde taak uit te voeren. In mijn onderzoek heb ik bekeken hoe mensen ondersteund kunnen worden bij het identificeren en beschrijven van competenties. Uiteindelijk heb ik hiervoor een instrument ontwikkeld: de website COMET, wat staat voor Competency Modelling Toolkit. Ook heb ik onderzocht of mensen met behulp van COMET beter in staat zijn om competenties in kaart te brengen. En dit bleek inderdaad zo te zijn.

Met andere woorden: mijn onderzoek heeft een praktisch instrument opgeleverd waarmee mensen in het onderwijs (bijvoorbeeld docenten en curriculumontwikkelaars) op een gestructureerde manier competenties in kaart kunnen brengen. Ook weten we nu op welke manier je mensen hierbij het beste zou kunnen ondersteunen.

> Knorretje probeerde Poeh te helpen.
> “Meestal begint het er toch mee dat je Trek krijgt, hè Poeh?” zei hij.
> Poeh knikte langzaam.
> “Ja-aa”, zei hij toen. En toen kreeg hij een inval. “Het helpt ook als ik een Lied zing”.
> Uil keek een beetje bedenkelijk.
> “Hoe bedoel je?” vroeg hij.
> “Nou”, zei Poeh, “ik heb Trek, en dan komt er vanzelf een Lied. En even later vind ik dan Honing,” Hij dacht even na en zei toen: “En ik vind nóg sneller honing als Knorrie bij mij is, he Knor?” En Knorretje glunderde van plezier.

“Ja”, zei Poeh toen beslist. Het Vinden van Honing gebeurt door Trek in het Eén of Ander, door een Lied en door Vriendschap.” En hij nam weer een lik van zijn honingraat.
Uil keek nog even moeilijk, maar toen begon hij toch te schrijven. Toen hij klaar was zag het er zó uit:

COMPETENTIES VAN POEH-BEER
(voor het Vinden van Honing)

(1) Het hebben van Trek in het Eén of Ander
(2) Het Zingen van een Lied
(3) Vriendschap.

Dankwoord

Graag wil ik op deze plaats een aantal mensen bedanken voor hun ondersteuning, bemoediging en vriendschap.

Op de eerste plaats bedank ik mijn promotor, Jeroen van Merriënboer, voor zijn grote betrokkenheid en inzet bij dit onderzoek. Jeroen heeft een grote mate van wat ik "cognitieve helderheid" zal noemen, waardoor hij uitstekend in staat de rode draad van een onderzoek te waarborgen. Vooral tijdens het schrijven van artikelen heb ik hier heel veel van geleerd. Ook stel ik het zeer op prijs dat Jeroen bereid was om nu en dan veel tijd in mijn onderzoek te steken, naast zijn vele andere werkzaamheden, en op de meest rare momenten. Dus Jeroen: bedankt, ik heb enorm geboft met jou als promotor!

Ook wil ik mijn dagelijks begeleider Rob Martens bedanken. Rob heeft zichzelf altijd als een "bezorgde coach" getypeerd en dit ook waargemaakt. Als hij het idee had dat het niet helemaal de goede kant op ging met het onderzoek, was hij degene die met een bezorgde, vaderlijke blik zijn bezorgdheid uitsprak. Maar ook was hij degene bij wie ik waardering kon oogsten in de vorm van een "enkele duim" (wat zoveel betekent als *goed gedaan*), een "dubbele duim" (*magnifiek*) of een reeks titels waarbij het aantal de mate van waardering bepaalde (prof. dr. mr. ir. Stoof staat dan voor *fenomenaal*). Rob, heel erg bedankt voor de goede begeleiding!

Vervolgens wil ik Ingrid Jonkman bedanken, de "spil" van de tweede verdieping in het Chiba-gebouw als het gaat om sociale contacten en praktische aangelegenheden. Ingrid was één van de personen met een Groot Luisterend Oor bij blije en minder blije momenten. Daarbij heeft Ingrid grote hoeveelheden data in SPSS ingevoerd en berekeningen gemaakt. En hoewel ze dit allemaal niet zo bijzonder vindt, vind ik dat wel heel bijzonder. Ingrid, mijn hele grote dank!

Onmisbaar zijn ook mijn beide studentassistenten geweest: Chris Lehnen en Ronald de Vries (over Ronald straks nog meer). Bedankt voor het invoeren van de data, het testen van vragenlijsten en practicumopdrachten, en het programmeerwerk!

Een andere persoon die ook zeer nauw bij mijn onderzoek betrokken is geweest is Ankie Meeussen. Van november 2003 tot en met mei 2004 heeft ze zich als stagiaire van de Universiteit Maastricht onder mijn hoede gesteld en een mooie scriptie geschreven over de kwaliteit van competentiedefinities die met behulp van COMET waren gemaakt. De eerste dag al werd ze in het diepe gegooid, aangezien we direct met een grootschalig experiment aan de Universiteit Gent begonnen. Dit deed ze voortreffelijk en met veel enthousiasme en dat is daarna ook zo gebleven. We hebben veel van elkaar geleerd en heel prettig samengewerkt. Ankie, de Lasagna Castart zal ik nooit meer vergeten!

Tenslotte zijn er nog de personen uit mijn promotie-begeleidingscommissie die inhoudelijk betrokken zijn geweest bij mijn onderzoek: Marcel van der Klink, Jo Boon en Kathleen Schlusmans (Open Universiteit Nederland); Leo Plugge (Stichting SURF); en Martin Valcke (Universiteit Gent). Als adviseur is betrokken geweest Wil Verreck (Digitale Universiteit). Bedankt voor jullie bijdragen en de kritische kanttekeningen!

Verder gaat mijn dank uit naar de personen en instanties die aan mijn onderzoek hebben meegewerkt: Ada van Arkel, Jim Bijlstra, Ramses de Groot, Douwe van der Hucht, Judith van Leuken, Heidi van de Loosdrecht, Riet Prins, Hinke Stellingwerf en Paul Zwartkruis van Hogeschool Diedenoort; Hilde van Keer, Franky Maes, Martin Valcke, Bram de Wever en alle eerstejaars studenten Pedagogische Wetenschappen van de Universiteit Gent; René Douma, Hans van Drongelen, Annelies Geerbex en Paula Jung van Hogeschool Zuyd; Ad Blokland (Amsterdamse Academie / Hogeschool Holland); Frans Dekker (Mondriaan Zorggroep Heerlen); Gerard Dukker (Hogeschool voor Economische Studies); Mirtel Gommans (Mondriaan Zorggroep Heerlen); Bianca Jennissen (Mondriaan Zorggroep Heerlen); Huub Meessen (Mondriaan Zorggroep Heerlen); Jan Schulpen (Prins Claus Centrum Sittard); Roger Thijs (PAAZ - AZM Maastricht); Eugène Thijssen (Fontys Hogeschool); Lily von Tongelen (Riagg Maastricht); en André Visbach (Riagg Roermond).

In het bijzonder wil ik Hans Tilman (Hogeschool InHolland / onderwijs- en organisatieadviesbureau Watchful) bedanken. Vanuit zijn expertise op het gebied van competenties, competentiegericht onderwijs, competentiekaarten en onderwijsontwikkeling in het algemeen is hij bij verschillende onderdelen van het onderzoek zeer actief betrokken geweest. Hans, bedankt voor je onmisbare input en de fijne samenwerking!

Naast degenen die inhoudelijk en onderzoeksmatig hebben bijgedragen aan het onderzoek waren natuurlijk ook mijn collega's bij het OTEC onmisbaar. In het bijzonder wil ik mijn mede-promovendi en de junior onderwijstechnologen bedanken voor de gezelligheid, collegialiteit, Eerste Hulp Bij Promotieongevallen, en Luisterende Oren. Vooral de lunch (stipt om 12.00 omdat anders de lekkerste broodjes al op waren) en aansluitend de lunchwandeling in de velden bij de campus zal ik nooit vergeten. Ik zal jullie missen!

Ook kijk ik terug op een leuke tijd met de collega's van de BHV (Bedrijfshulpverlening), met wie ik een aantal jaar brandjes, kwetsuren en andere calamiteiten op de Open Universiteit Nederland voor mijn rekening heb genomen (dat waren er gelukkig zeer weinig!). Vooral het tijdens de oefeningen stevig inpakken en insnoeren van "slachtoffers" op een brancard, om die dan vervolgens moederziel alleen in de lift achter te laten staat in mijn geheugen gegrift!

Het spreekt vanzelf dat mijn familie en vrienden ook een onmisbare steun zijn geweest in de afgelopen tijd. Zij vormen toch de grond waarop je kunt staan en op terug kunt vallen als het even wat moeilijker gaat. Van deze grote groep bijzondere mensen wil ik er een paar speciaal bedanken.

Mijn ouders hebben altijd achter me gestaan en Heel Grote Luisterende Oren geboden. Ze hebben vaak ook meegedacht, niet zozeer inhoudelijk, maar meer over de vragen, uitdagingen en complicaties die een werkend bestaan met zich meebrengt. Uiteindelijk moet je toch zien uit te vinden wat je plek is: wat je wilt doen en hoe je dat wilt doen. Ik denk dat de antwoorden op deze vragen de grootste opbrengst zijn van de periode waarin ik aan mijn promotieonderzoek heb gewerkt. Papa en mama, wat zou ik toch zonder jullie moeten. Bedankt voor alles!

Ook wil ik twee vriendinnen bedanken, die het aandurven om me tijdens de promotie terzijde te staan: mijn paranimfen Marije Duijsens en Dineke Tigelaar. Marije, we kennen elkaar nu al sinds onze studententijd in Maastricht en hebben sindsdien veel lief en leed met elkaar gedeeld. Je bent een geweldige vriendin en ik vind het een eer dat je me op de grote dag terzijde wilt staan! Dineke, wij kennen elkaar van themagroepen en symposia over competenties. Vanuit een gedeeld onderzoeksonderwerp hebben we echter meer dingen ontdekt die we gemeen hebben, vooral als het gaat om verdieping in en bezinning op het leven dat we leiden. Ik vind het heel bijzonder dat ik je heb leren kennen en ik ben ontzettend blij dat ook jij naast me staat tijdens de promotie!

Dan wil ik nu eindelijk dit lange dankwoord afsluiten met een Woord van Dank aan Ronald. Ronald was niet alleen studentassistent, maar vooral ook de Grote Stabiele en Motiverende Factor, met het Grootste Luisterende Oor van allemaal. Niemand heeft zoveel frustraties over zich heen gekregen als Ronald en niemand heeft van zo nabij alle kleine en grote overwinningen meegemaakt. Ronald, je bent een super-lieverlie en ik ben ontzettend blij met jou!

Angela Stoof

Maastricht, januari 2005

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1
Introduction

Abstract. The introduction consists of three parts: (1) the general research problem of the dissertation, including the background of the problem; (2) the approach that was used to solve the problem; and (3) the structure of the dissertation and the research questions. The general research problem is: Which tools can support the identification and description of competencies as a basis for competence-based education? This problem is approached in three steps: explorations, tool development and experimental evaluation. Explorations focus on the concept of competence and on the bottlenecks that designers encounter in identifying and describing competencies. Tool development concerns the construction of a valid and practical tool that supports designers in identifying and describing competencies. In the experimental evaluation, the effects of the tool are measured. The structure of the dissertation follows the three-step approach.

1.1 Problem definition

In the last decade, great attention has been paid to competence-based education. Although the use of the term competence in education is not new (e.g., Houston & Howsam, 1972), competence-based education is currently flourishing in several countries. In particular, educational designers, researchers and developers in the Netherlands collectively embraced the concept of competence as a means to develop modern education. In addition, competence-based education is an important issue in for example Australia and New Zealand (Mulcahy, 2000), and the USA and UK (Barnett, 1994). Competence-based education is often characterized by a focus on authentic professional situations, tasks and roles, from which the learning content is derived; authentic assessment in the beginning, during and at the end of the learning process; integration of learning contents instead of fragmentation; the student as a planner of his of her learning path; and the teacher as a coach (de Bie, 2003; Schlusmans, Slotman, Nagtegaal, & Kinkhorst, 1999). It is generally believed that competence-based education is an answer to societal changes. In particular the professional environment has become more complex, dynamic and knowledge intensive and it requires employees who are well educated, versatile and able to maintain their personal knowledge and skills (Bastiaens & Martens, 2000; Cluitmans, 2002; Mulcahy, 2000; Schlusmans et al., 1999). The concept of competence is a means to think about these changes and requirements.

The development of a competence-based curriculum begins with the identification and description of the competencies that students should acquire. To put it in other words, one has to describe the final attainment levels of the educational program in terms of competencies. The product that results from this analysis is variously designated as a *competence map* (Schlusmans et al., 1999), a *competence profile* (Cluitmans, 2002; de Bie, 2003), or variants on these labels. In this dissertation, the term competence map is used. Typically, a competence map is developed by a heterogeneous team, consisting of stakeholders such as curriculum developers, teachers, educational managers, field experts and branch representatives. Together they collect information about the competencies within the domain of interest, identify the competencies, and describe them in a competence map. This is a highly complex and difficult process, as all processes of curriculum development are (de Bie, 2003; McKenney, Nieveen, & van den Akker, 2002).

It is obvious that a competence map has important implications, since it constitutes the basis of a competence-based curriculum. Taking this importance into account, as well as the complexity of the development process, it is surprising that little practical guidelines or tools are available to support people in constructing competence maps. In particular, instructional design tools that support the development of competence maps are expected to lead to improved task performance, increased task-related knowledge, increased satisfaction and increased internal consistency of the output (Gery, 1991; McKenney, Nieveen, & van den Akker, 2002; Stevens & Stevens, 1990). However, most instructional design tools are authoring tools for developing computer-based instruction. Little attention is paid to the analysis of curriculum content, in terms of competencies or otherwise (van Merriënboer & Martens, 2002). Thus, the general research problem of this dissertation is: *Which tools can support the identification and description of competencies as a basis for competence-based education?* The answers to this important question are needed for the development of high-quality competence-based curricula. Therefore, this dissertation is of main importance to all kinds of people who are involved in the development of competence-based education. In addition, the answers to the posed question also contribute to instructional design models, in particular to the neglected area of curriculum content analysis. Thus, this dissertation is of main interest to instructional designers as well.

1.2 Approach

The posed research question can be solved with a three-step approach: (1) explorations; (2) tool development; and (3) experimental evaluation.

Explorations

To begin with, explorations of two topics are needed. First, the concept of competence has to be analysed. It has to be clear what competence means before designing a tool that supports the construction of competence maps. Since a lot of articles have been devoted to the issue of competence and competence-based education, this analysis can be based on a literature review. Second, the process in which competencies are identified and described has to be analysed. The complexity of this process is beyond dispute, but it is of great interest to unravel this complexity and to investigate the bottlenecks that appear in the development process. Such an analysis will foster the development of a tool that meets the needs of the intended users. The analysis can be based on a literature review within the areas of competence-based education, competency analysis and curriculum design in general. In addition, explorative studies focusing on teams who make competence maps may provide valuable first-hand information about the actual processes and bottlenecks.

Tool development

The second step is to develop a valid and practical tool that supports designers in constructing competence maps. *Validity* implies that the tool is based on state-of-the-art knowledge and that the components of the tool are consistently linked to each other. *Practicality* holds that users and other experts consider the tool as appealing and usable under normal conditions (van den

Akker, 1999). The type of support must closely match to the bottlenecks that are identified in the explorations within the first step. Also, the support must be based on a solid theoretical framework that allows the formation of hypotheses. In order to obtain a practical tool, design choices should be based on a thorough analysis of the output, the target group, their needs and the context in which the tool will be used. Also, usability aspects and instructional design requirements in general may be considered. A strong and successful method that is often used for tool development is *evolutionary prototyping*. Here, parts and preliminary versions of the tool are repeatedly tested with intended users and improved until a final delivery has been attained (Nieveen, 1999).

Experimental evaluation

In addition to the requirements of validity and practicality, a tool also needs to be *effective* (van den Akker, 1999). Therefore, the third step is to evaluate the effects of the tool and in particular the effects of the constituting elements. Dependent variables are the quality of the process in which a competence map is made; the quality of the products that result from this process (i.e., the competence map and intermediate products); and the learning effect on competence maps and how they are constructed. Expectations can be based on the theoretical framework of the tool. An important consideration in the experimental design is the balance between ecological validity on the one hand and powerful, controlled measurements on the other hand. Because of the characteristics of the situation in which competence maps are normally developed, it is impossible to combine these two goals in one single study. In "normal" situations, competence maps are developed by a project team that consists of eight persons maximally. Such small group sizes do not allow powerful statistical tests. In addition, the development process normally takes several weeks to months, with several face-to-face meetings and additional communication via email and telephone. This makes it difficult to obtain controlled measures. A solution to this problem is to conduct two experiments: a large-scale, controlled study and an small-scale, ecologically valid study.

1.3 Structure of the dissertation and research questions

The structure of this dissertation follows the three-step approach as described above.

Part A refers to the first step: *explorations*. Chapter 2 focuses on the meaning of competence. It concludes that there is no generally accepted definition of competence. It also states that in defining competence, one should not strive for one absolute definition but instead for a definition that is useful or *viable* in the situation in which it is used. Although the chapter focuses on human resource developers[1], the problems with the meaning of competence are similar in the area of education. Therefore, the text applies to educationalists and curriculum designers as well. The central research question in this chapter is: How can human resource developers and educationalists be supported in constructing a viable competence definition? It is argued that viability increases when a definition is based on an analysis of the variables people, goal and context. The main part of this chapter is about the *boundary approach of competence*, which is a conceptual aid to think about the term competence and to construct a competence definition.

Chapter 3 describes the bottlenecks that project teams encounter in developing a competence map. It argues that these bottlenecks do not occur only during the development of competence maps, but in all processes in which curriculum content is determined and described. The research questions are: (1) What are the main bottlenecks that design tams encounter in determining and describing curriculum content? and (2) What kind of supportive tools may be developed for overcoming these bottlenecks? The bottlenecks were identified in three explorative studies: a questionnaire study and two case studies on teams that were constructing a competence map. It appears that there are two main bottlenecks: *conceptual bottlenecks*, concerning the meaning of competence and the difference between competence and related terms; and *procedural bottlenecks*, that have to do with a lack of methods for describing and ordering competencies into a structured overview. Also, this chapter provides suggestions for supportive tools that help people in overcoming the bottlenecks.

Part B of the dissertation focuses on *tool development*. Chapter 4 describes the design and formative evaluation of a tool that supports the construction of competence maps. The central research question is: What are the characteristics of a valid and practical tool that supports designers conceptually as well as procedurally in constructing competence maps? The conceptual support is based on *dimensions* of competence. Dimensions provide guidance to think about the term competence, and at the same time they allow flexibility in choice and personalization of a competence definition. The procedural support follows this flexibility and is adaptive to all kinds of competence definitions. It distinguishes four steps: generation of a linguistic format; data collection; data analysis; and ordering competencies in a general framework. The conceptual and procedural support are part of a larger process in which a competence map is developed. This process consists of four phases: initiation, construction, validation and acknowledgement. Each phase consists of several steps, which are supported by four types of aids: a task manager, an information bank, a construction kit and a phenomenarium.

[1] Chapter 2 focuses on human resource developers because it has been published earlier in Human Resource Development Review.

The chapter also describes the evolutionary prototyping procedure that was used for developing the tool. The tool is designated as *COMET*, which is a loosely acronym for Competency Modelling Toolkit. Evaluations of four prototypes with intended users, domain experts, internet users and web designers show that COMET is practical. The chapter concludes with an extensive description of COMET from three perspectives: the user, the curriculum developer and the instructional designer.

Part C concerns the *experimental evaluation* of COMET. Chapter 5 describes a large-scale evaluation of COMET in a well-controlled setting. In a factorial experiment, Educational Science students individually constructed various parts of a competence map. They were supported with one of the eight versions of COMET, containing a task manager, a construction kit (present / absent), a phenomenarium (present / absent) and an information bank (full / condensed). The research questions are: (1) Do a construction kit, phenomenarium, and information bank improve the process quality of making a competence map? (2) Do they improve the quality of the products that result from this process? (3) Do they have a positive effect on learning to construct competence maps? Results show positive effects of the construction kit and the phenomenarium on perceived process quality and learning. In addition, there are indications that a condensed information bank is more effective than a full one with respect to perceived product quality.

Chapter 6 describes a small-scale experiment in an ecologically valid context. During six weeks, two teams constructed a competence map, within the same setting and with the same purpose. Both teams were supported with a task manager, a full information bank, and a phenomenarium. In addition, one team was supported with a construction kit, whereas the other team was not. Because the results of the first experiment were not available in time, the second experiment uses a full information bank instead of a more beneficial reduced one. The research questions are: (1) Does a construction kit for the development of a competence map improve the quality of the development process, and (2) Does it improve the quality of the final product, that is, the competence map itself? Similar to the first study, results show that the availability of a construction kit improves perceived process quality. Qualitative measures show that if a construction kit is lacking, participants seem to compensate for this by using additional ad-hoc strategies for gaining support, such as collecting more information about related development steps and consulting more experienced colleagues in their team.

The dissertation concludes with Chapter 7, which is the general discussion of part A, B and C. It summarizes the main conclusions of the work; describes the implications in terms of design guidelines; discusses the limitations with respect to the research focus, design and deviating results; and provides directions for future research in this area.

In addition to the chapters, the dissertation includes an Appendix containing examples of the supportive aids in COMET; summaries in English and in Dutch; a list of publications of the author; and a curriculum vitae.

The instruments and materials that have been used in the research are not included in this dissertation.

COMET is available on: http://www.ou.nl/open/ast/comet_eindversie. This version of COMET includes a task manager, a construction kit, a phenomenarium and a full information bank. For information about other instruments and materials, please contact the author. The address of the author can be found on the copyright page.

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Part A: Explorations

Contents:

2

The boundary approach of competence: a constructivist aid for understanding and using the concept of competence[2]

Abstract. Although competence is an important concept in HRD and education, there is no theoretical framework for competence. This article focuses on the development of such a theoretical framework. It proposes the boundary approach of competence, an aid to support human resource managers and educationalists in thinking about the concept of competence and in defining it properly. Here, the concept of competence is being explored by focusing on its dimensions and by identifying differences with related terms. The boundary approach of competence heavily depends on a constructivist point of view. This holds that the quest for one absolute meaning of competence is being abandoned and that instead competence definitions are being valued against their degree of viability. This article proposes three variables for enhancing viability: people, goal and context.

[2] This chapter has been published as: Stoof, A., Martens, R. L., Van Merriënboer, J. J. G., & Bastiaens, T. J. (2002). The boundary approach of competence: a constructivist aid for understanding and using the concept of competence. *Human Resource Development Review, 1*, 345-365.

2.1 Introduction

Today, the concept of competence is increasingly used in many organizations. Particularly business organizations and educational institutes are eager to use the term competence to refer to instruments for human resource development (HRD) or to new educational methods. This article argues that despite the importance of the concept of competence there is no theoretical framework for competence and consequently no definition of competence. It focuses on the development of such a theoretical framework, thereby supporting human resource developers and educationalists in understanding and using the concept of competence.

An example of an organization that is using the concept of competence in HRD is the British/Dutch oil company Shell. For example Shell has developed a method for the process by which the required competence levels for any specific role or position in the business are defined. The key process of this "competence mapping" method is a gap analysis which gives an insight in the required competence level and the present competence level of an individual or a team. The method ensures the company that performance requirements are fully defined.

Another example of adapting the concept of competence is distance education. Distance education universities such as the Open University of the Netherlands, are aiming more and more at competence based curricula (van Merriënboer, 1999). They do this in an attempt to face the criticism that distance education is too much oriented towards theory and too little towards the complex skills that future employees need. The same criticism can be heard against electronically distributed education in general, which can be seen as a special form of distance education. With tools such as Blackboard, Edubox, Frontpage, Profes-E, and Web CT, web based education is flourishing. In an attempt to make this education more "authentic" and to find the right connection with HRD in companies, the term competence is often used.

It is often believed that the concept of competence somehow aims at an authentic combination of knowledge, skills and attitudes that employees really need, thus providing better and more useful education, both in educational institutes and in HRD. However, this may be misleading. In some cases, already existing methods and management instruments are relabeled with the term competence to suggest a halo of progressiveness and excellence. This is largely due to the elusiveness of the concept of competence. Despite the increasing popularity of the term competence, there still is no widely accepted definition. Although there have been some attempts (e.g., IEEE Learning Technology Standards Committee, 2000; Salganik, Rychen, Moser, & Konstant, 1999), there is no reference point that can be used in evaluating competence approaches. Consequently, there are many different definitions and operationalisations of the term competence (for some examples, see Table 2.1). This leads to confusion, not only among the students that attend competence based study programs and employees that are subject to competence development, but also among training and development professionals that have to develop competence based training and competence management (Bos, 1998b; Fletcher, 1997). It may be clear that this is a large problem. On the one hand, the concept of competence appears to be very attractive to HRD and education. On the other hand, the meaning of competence is very unclear, thereby disabling human resource developers and educationalists to successfully work on competency development of individuals.

Table 2.1: Examples of competence definitions.

"Competency is a knowledge, skill, ability, or characteristic associated with high performance on a job, such as problem solving, analytical thinking, or leadership. Some definitions of a competency include motives, beliefs and values." (Mirabile, 1997, p. 75).
"A competency is: a cluster of related knowledge, skills and attitudes that affects a major part of one's job (a role or responsibility), that correlates with performance on the job, that can be measured against well-accepted standards, and that can be improved via training and development." (Parry, 1996, p. 50).
"A competency is an underlying characteristic of an individual that is causally related to criterion-referenced effective and/or superior performance in a job or situation. Underlying characteristic means the competency is a fairly deep and enduring part of a person's personality and can predict behavior in a wide variety of situations and job tasks. Causally related means that a competency actually causes or predicts behavior and performance. Criterion referenced means that the competency actually predicts who does something well or poorly, as measured on a specific criterion or standard." (Spencer & Spencer, 1993, p. 9).
"Competence [is the] ability to handle a situation (even unforeseen)." (Keen, 1992, p. 115). "Competence is a compound, made up of different parts just like the fingers of a hand [i.e., skills, knowledge, experience, contacts, values, and additionally coordination which is located in the palm, and supervision, symbolized by the nervous system]." (Keen, 1992, p. 112)
"Human competence […] is displayed behavior within a specialized domain in the form of consistently demonstrated actions of an individual that are both minimally efficient in their execution and effective in their results" (Herling, 2000, p. 20).

Thus, a central question is: What is competence? This question may evoke related questions such as: Which competence definition is the best? Are other definitions wrong? What is competence really? Although legitimate, these questions often have an *objectivistic* point of view lying behind. *Objectivism* is one of the two fundamental approaches in epistemology (Valcke, 1999; Yeaman, Hlynka, Anderson, Damarin & Muffoletto, 1996). Objectivists consider the world as given, meaning that there is one objective, absolute truth. This article argues that confusion about the concept of competence partly arises from this objectivist point of view because discussing competence definitions over and over again in order to reach consensus about the one and only true meaning of competence is a "dead-end road". The one and only true competence definition does not exist, nor will ever be found. In contrast, a *constructivist* approach releases the quest for the absolute truth about competence by allowing a variety of competence definitions. Here, the criterion for a competence definition is not whether the definition is true, but the extent to which the constructed definition has proven to be adequate in the context in which it is used (i.e., *viability*, Von Glaserfeld, 1995). A quest for the most viable competence definition seems to be much more fruitful. A constructivist approach does not aim at describing a concept that is extremely hard to grasp, but it rather redirects the attention of the people concerned to their own situation and their own needs, in order to construct a viable competence definition.

A constructivist view on competence is not new, although it is rarely explained in constructivist terms. For example, Parry (1996, p. 48) wonders: "How specific or generic should competence definitions be? The answer depends on how the competences will be used and the purpose of the study." According to Eraut (1994, p. 166), "new areas of competence get defined in ways which best suit the existing expertise of the colonizing profession. This is not necessarily a deliberate strategy, as people naturally define problems in ways determined by their background knowledge and experience." Mirabile (1997, p. 76) states that ,"the most important point about competency models is that the formats be governed by the collective wisdom of the people that need and build them." As a final example, the OECD which is the Organization for Economic Co-operation and Development, adopts a constructivist position in their DeSeCo program (Definition and Selection of Competences: theoretical and conceptual foundations). Rather than using an overarching strategy in various sub-projects "the process of definition has been largely determined by individual initiatives and particular national interests" (Salganik, Rychen, Moser, & Konstant, 1999, p. 7).

However, despite these constructivist notions these authors do not provide guidelines for actually defining competence. This article fills this need by adding the boundary approach of competence, which is an aid to think about the concept of competence and to define it properly. Thus, unlike many other publications on the meaning of competence (see Table 2.1), this article does not give an operational definition of competence. Rather, it supports people in constructing their own viable competence definition.

To sum up, it is clear that the concept of competence is a keyword in HRD as well as in education. It is being used in developing, training and educating employees and students in such a way that they are able to meet the demands of work. At the same time, there is no sound theoretical framework for competence and consequently no sound definition of competence. This article initiates the development of such a theoretical framework. The central question is: How can human resource developers and educationalists be supported in constructing a viable competence definition? The first section introduces the concept of competence. It focuses on the recent history of the concept of competence in business organizations as well as in education. The second section elaborates on a constructivist approach of competence by proposing three variables that may increase the viability of a competence definition: people, goal and context. These variables redirect attention to the situation in which a competence definition is being constructed, instead of immediately focusing on the precise meaning of competence. The third section is the heart of this article. It discusses the boundary approach of competence, which is an aid to think about the concept of competence and to define it properly, in a constructivist way. The boundary approach of competence may be regarded as a first step towards a theoretical framework for competence.

2.2 The recent history of competence

The background and roots of competence offer a first step towards a closer understanding of the variety of competence definitions and approaches. In this variety, two main movements have been distinguished (Bos, 1998a): the competence movement in business organizations and the competence movement in education. Although these two fields are related, their backgrounds are totally different, as will be discussed in the next two sections.

2.2.1 From recruitment and selection to "core competence" in business organizations

The term competence is not new. According to Webster's Dictionary, its roots go back to 1596. However, the past decades the influence of the concept of competence has increased substantially. It seems that the concept of competence became influential in business organizations in the first place, more specifically in the field of recruiting and selecting new employees. The article of David McClelland (1973), "Testing for competence rather than for intelligence", may be considered to be the starting point of the competence movement (Barrett & Depinet, 1991). In his article, McClelland argued that commonly used I.Q. and personality tests were poor predictors of successful performance, and that competence assessment should be developed as an alternative. He developed the Behavior Event Interview (BEI), an interview method that combines Flanagan's Critical Incident Method (Flanagan, 1954; elaborated by Dailey, 1971, and Boyatzis, 1982) with the Thematic Apperception Test (TAT; e.g., McClelland, 1989). The BEI is used to discover differences between persons who have been nominated by knowledgeable judges as outstanding and those who have been nominated as typical (i.e., average). The underlying assumption is that people have less difficulty with deciding who is competent than what makes them competent (McClelland, 1998). Lyle and Signe Spencer' s book "Competence at work: models for superior performance" (Spencer & Spencer, 1993) elaborates on McClellands work when it summarizes the findings of 286 studies conducted in various types of organizations, resulting in a competence dictionary for 21 competences that distinguish superior from average performers in middle- to upper-level jobs.

Both McClelland and Spencer and Spencer can be considered as representatives of the competence movement in the field of human resource development (HRD). In HRD the focus is on recruiting, selecting, employing, assessing, training and developing employees (e.g., Weinberger, 1998). Rothwell (1996, p 263) defines a competency as the underlying characteristics of successful performers which can include bodies of knowledge, skills, traits, abilities, attitudes or beliefs.

In addition, competence nowadays is also approached at the higher level of organizational strategy and competition, often referred to as *core competence* (Prahalad & Hamel, 1990; Quin, 1992). Core competence is the unique ability of organizations to deliver products or services. This ability is rather constant, is hard to copy by other organizations and is the basis for the benefit of the organization.

2.2.2 Teaching competences

Besides business organizations, educational institutes too have paid great attention to competence. However, the origin and development of the competence movement within the educational field is less clear. Mulder (1998) mentions two approaches which go back to the seventies, and originated in the schools of Skinner and Maslow respectively: competency based teacher education (CBTE) and humanistic based teacher education (HBTE). However, in the educational field there is no clear historical line as in business organizations. A possible explanation may be that the competence movement originated in business organizations and that the competence movement in the educational field is a response to and derivation of the developments in business organizations. Professional organizations are often customers of educational institutions (Everwijn, 1999), which makes it plausible that educational institutes try to satisfy the demands of employers. McClelland and others stimulated an increasing focus on competence in professional organizations, starting at the level of HRD, broadening to the level of organizational strategy. Consequently, in the educational field the problem arose as to how to educate people in such a way that they would develop competences. Questions arose such as: Is competence something that can only be acquired in a working environment? Is there a difference between competence of a fresh graduate and an experienced professional? In addition, there is the overriding question: can competence be taught? (e.g., Parry, 1996; Spencer & Spencer, 1993).

Whether competence can be taught, and whether it can be taught outside real working situations, depends on the meaning of competence. In practice, this question often does not have the attention it should have. Education is an ongoing process, and educationalists often have other urgent things to do than reflect deeply on what competence is. Consequently, definitions of others are used, definitions that often originated in the business context. The same problem occurs when competence is analysed. The way it is analysed is often duplicated from other competence analyses, without many theoretical considerations (Bos, 1998a; 1998b).There is a tendency among educationalists to focus quickly on the method: *how* to teach competence, rather than answering the question: *what* competence do we want our students to learn?

2.3 Increasing viability: analysing the situation

As stated in the introduction, the aim of this article is not to give an objectivist answer to the initial question: What is competence? Rather, this article adopts a constructivist point of view. A constructivist approach of competence essentially holds that people's attention is being redirected to their own situation and their own needs, instead of searching for the absolute meaning of competence. The keyword in a constructivist approach is *viability* (Von Glaserfeld, 1995). This means that a definition of competence should be adequate for the situation in which it is being used.

This article proposes three variables that increase the viability of a competence definition: people, goal, and context. These variables may help people in redirecting their attention to their own situation. This section describes this variables, and concludes with guidelines about how to use them in defining competence in HRD situations.

People

Often, constructing a competence definition is an activity that is not being performed by an individual but by a team. In most cases, defining competence is an aspect of a larger project, like human resource development or curriculum design. Such extensive activities often have many stakeholders that are represented in the team that constructs a competence definition. Individual team members are likely to have different representations of and opinions about the concept of competence, which are probably closely connected to their background and expertise. For example, people with a background in training are likely to think of competence as something that can be taught (e.g., Parry, 1996, see Table 2.1). It is important to be aware of the existence of these differences. It is crucial to construct an agreed definition with clear underlying assumptions. Such an agreed definition will enhance its viability.

Goal

The way a competence definition is constructed also depends on the goal of the competence definition. Here, the central question is: What is the definition going to be used for? There are a lot of possibilities, such as training design, recruitment and selection, redefining roles, improving work processes, developing competence-based education and building a framework for reward systems (see for an extensive overview, Fletcher, 1997). Defining competence in such a way that it covers a whole range of possible applications often leads to definitions that are too global and too abstract. Such definitions may be unworkable, thereby decreasing the viability.

Context

Context refers to the broader organizational level. What does the organization do? What products or services does it supply, and to whom? In what organizational processes is the definition going to be used? Who are the intended users of the definition? The context is especially important when a competence definition is going to be used in the organization. The definition should fit into existing organizational processes and should be easy to handle by the intended users. A definition that is being ignored or incomprehensible will certainly not enhance the viability.

In an HRD situation, people who are involved in constructing a competence definition may use the three variables of people, goal and context to focus on their own situation. Considerations and choices about these variables are the point of departure for subsequent discussions. For example, a human resource manager in a scientific institute may have a very different opinion about competence than a researcher from the same institute. Without clarifying these opinions there is a serious danger of miscommunication, because the word "competence" has different meanings to different people. Discussing the variable "people" helps to prevent this situation.

When the situation has been made clear by using the three variables, that is, when "noses point in the same direction", the constructivist process proceeds. It is time to start thinking about the meaning of competence and its definition. This process may be facilitated by the boundary approach of competence.

2.4 The boundary approach of competence

The boundary approach of competence is a visual and conceptual representation aid. It supports people both in thinking about the meaning of competence and in defining competence properly, in a constructivist way. Also, it is meant as a first step towards a theoretical framework for competence.

Figure 2.1 shows the concept of competence in an amoeba-like form. The amoeba represents competence as a limited and demarcated concept, which is expressed by drawing its boundary. The boundary is being shaped by two opposing forces, being visualized as arrows. From inside the figure, forces expand the boundary. This process is labelled as the *inside-out approach* of competence. This approach focuses on dimensions of competence, for example teachable competence versus non-teachable competence, competence as related to either task characteristics or personal characteristics, etcetera. On the other hand, the forces from outside the figure reduce the boundary, a process designated as the *outside-in approach* of competence. This approach incorporates terms that are related but not equal to competence, such as performance, the cluster of knowledge, skills and attitudes, ability and so forth. When people define competence, they stress certain dimensions or differences with related terms more than others. Metaphorically, they increase and decrease some forces in the boundary approach of competence, thereby altering the shape of the boundary. Thus, the boundary is dynamic. It allows all kinds of competence definitions, in line with the constructivist assumptions in this article.

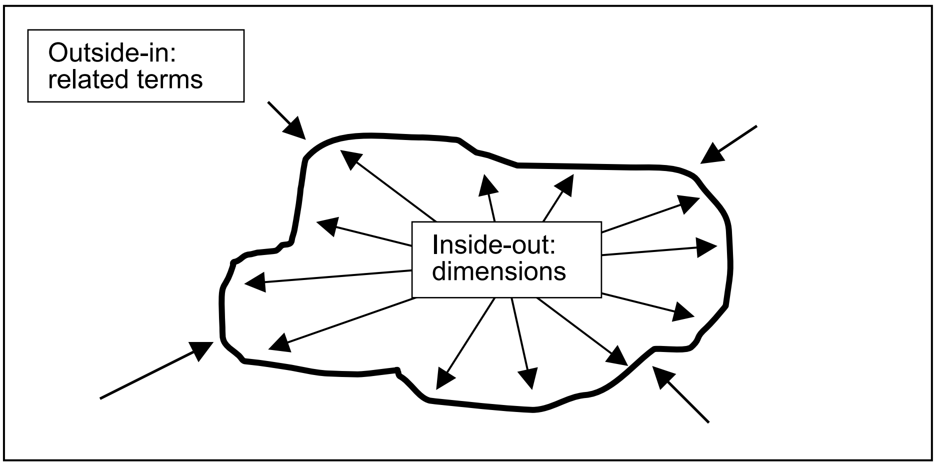

Figure 2.1: The boundary approach of competence: a visual and conceptual representation aid for understanding and using the concept of competence.

The next two sections discuss the inside-out approach and the outside-in approach in depth. Both sections conclude with clues for using these theoretical notions in constructing a competence definition in HRD situations. A third section concludes with notions about the actual construction of a competence definition, given the “ingredients” as delivered by the inside-out and the outside-in approach of competence.

2.4.1 The inside-out approach: dimensions of competence

The inside-out approach contains dimensions of competence. To begin with, the idea of a dimension will be described, using Figure 2.1 as a visual aid. A *dimension* may be visualized as a line with an arrow at each end. The ends of the line represent the two opposing extremes of a dimension, for example teachable competence versus non-teachable competence. These lines cross the space within the boundary, beginning somewhere on the boundary and ending on the exact opposite side of the boundary. While defining competence, people can take position somewhere on this dimensional line. For example, when they consider competence as something that can be taught, they will take position at the end of the line that represents "teachable competence". As a result, the point on the boundary that is associated with "teachable competence" subsequently bulges out, whereas the opposite side of the boundary withdraws. This is how the inside-out approach essentially works. The shape of the boundary alters with each dimensional choice that is made. This section discusses five dimensions.

1. Personal versus task characteristics.

The dimension personal versus task characteristics turns up in competence literature quite often (e.g., Derous, 2000; Fletcher, 1997; Parry, 1996; Thijssen, 1998). Many authors refer to it under the heading of "the USA versus the UK approach of competence", although this seems to be an oversimplification. This dimension is also known as competency versus competence, as competences versus competences, as input or process versus output, and as behavioural versus vocational competence.

Competence approaches that stress personal characteristics focus on the question: Which personal characteristics lead to superior performance? Here, competence is "an underlying behavioural dimension or characteristic that can result in effective and/or superior individual performance, depending on context, organization, environmental factors and job-specific characteristics" (Derous, 2000, p. 7). On the other hand, the central question in competence approaches that stress task characteristics is: What are the essential elements of the task that is to be fulfilled? Here, "employees display competences in the degree to which their work meets or exceeds prescribed work standards" (Parry, 1996, p. 48). In short, the task characteristics approach is about work and achievement, while the personal characteristics approach is about the people who do the work (Fletcher, 1997).

2. Individual versus distributed competence.

Another dimension of competence is to whom or to what it refers. On the one hand, competence may be viewed as something belonging to one single individual. Here, the focus may be for example on the training and development of competences of an employee, or on the assessment of a student's competences. On the other hand, distributed competence refers to more than an individual. It refers to a cluster of things that are closely bound in what may be called a "system", such as a team of people working together on a project, or an individual person that frequently uses aids like dedicated computer programs. A distributed view on competence essentially holds that competence is spread out on several "agents" whose competences cannot be viewed in isolation for they are interdependent.

A theory that might be related to the distributed approach that goes beyond the individual is *distributed cognition* (Salomon, 1993). Cognition is said to be distributed, meaning that it occurs not just in individual minds but through the cooperation of many individuals. It refers to social aspects of education and work. Often, people work and learn together, in teams. In some situations an individual cannot even perform a task alone. Another approach that is related to distributed cognition is *systems thinking* (Senge, 1990). Organizations and problems are often split up in parts. That makes them easier to handle, but a major disadvantage is that they become disconnected from the whole system, because they are taken out of context. In learning situations, for example, this could lead to transfer problems. Therefore, in systems thinking systems are approached as a whole.

3. Specific versus general competence.

Definitions of competence can be positioned on a continuum ranging from specific to general. It is about the scope of a competence definition. Specific definitions have a narrow scope, for example by taking account for one specific task in one specific company (e.g., managers in company X). Here, a competence definition only has to do with competences needed for this specific function, and is not useful for other tasks or other situations. On the other hand, general definitions have a much broader scope. For example, a more general definition of competence refers to competences within an entire domain of profession (e.g., managers in general), or even to professions in general, covering all possible professions and domains by considering competence as something that goes beyond specific professions and domains.

A related dimension is the dimension of universal versus crucial competence. When competence is related to task performance, competence definitions can refer to universal aspects of competence that contribute to task performance in general, or they can refer to specific aspects which are crucial to perform a specific task.

4. Levels of competence versus competence as a level.

Levels of competence refers to gradations. In this view, a person has a certain amount of competence. For example, an expert will be more competent than a novice, that is, an expert will have a higher level of competence than a novice. Thijssen (1998) distinguishes two levels of competence: threshold standards and excellent performance. Threshold standards refer to a minimal competence, necessary to perform a task but not in an excellent way. This level is often associated with exit behaviour of students and minimal requirements for new employees, assuming that competence will develop further throughout their career. The level of excellent performance is useful in specific situations, for example top education or selecting top managers. Parry (1996) recommends that in defining competence, levels of competence should be included, for example the level of novices, intermediate job holders, and seasoned professionals performing at a high level. A term that is related to levels of competence is proficiency: this refers to how much of a particular competency a person must have to be successful in his or her work (Mirable, 1997).

In contrast, competence can also be regarded as one particular level. Here, competence is a delineated stage, in between other stages. For example, competence may be approached as a stage in the development from novice to expert (e.g., Dreyfus & Dreyfus, 1986, Eraut, 1994; Fuller, 1970).

5. Teachable versus non-teachable competence.

Competence definitions often contain elements like knowledge, skills, attitudes, personality, motives, and so forth. When a definition of competence is going to be used for educational or training purposes, the question whether these elements can be taught becomes very important. Spencer and Spencer (1993) conceptualise this question in an iceberg model, in which skills and knowledge are "visible" and relatively easy to teach, whereas self-concept, traits and motives are "hidden" below the sea level, meaning they are more difficult to develop. In recruiting and selecting employees this problem can be solved by assessing desired personality characteristics in selection procedures, rather than training them later on. This solution normally does not apply to educational institutes, but one could imagine selection procedures that precede enrolment, assessing personality characteristics of candidate students.

Parry (1996), distinguishes soft and hard competence. Hard competence refers to job-specific abilities (such as job-related knowledge and skills), whereas soft competence refers to personality traits, values and styles. Although he admits that soft competence affects performance, he chooses not to include it in his definition of competence because he does "…not see them as competences to be developed through training" (Parry, 1996, p. 50). When competence is not divided in elements but is approached as a whole, the teaching question remains: can competence be taught? The answer again lies in the way competence is defined.

To conclude, how can these five dimensions be used in defining competence in HRD situations? The major function of the inside-out approach is to draw attention to some aspects of the concept of competence, aspects that may be ignored while constructing a competence definition. It shows that the concept of competence has a large scope, that may be characterized by various dimensions such as the ones described above. It also shows that constructing a definition of competence is a matter of making choices. The inside-out approach supports this process of decision making. Every dimension represents a question, such as: Do you want to stress task characteristics or personal characteristics in a competence definition, or: Do you want to treat competence as teachable or not? These questions may unravel hidden assumptions that people have about competence. Or, the questions may force people to think about issues that they did not recognize before. For example, when a competence definition is being constructed within a HRD situation, people may discover that they favor a distributed view of competence. Possible consequences of such a choice may be that developing the competences of employees means developing competences of a "system" of employees, being a coherent part of an organization.

As a result of these essential choices, the conceptions that people have about competence will become clearer. This will facilitate the subsequent process of deciding which terms to use in the definition. This is the issue in the next section.

2.4.2 The outside-in approach: differences with related terms

Whereas the inside-out approach explores the meaning of the concept of competence, the outside-in approach focuses on the selection of terms that express the intended meaning of competence best. The inside-out approach expands the boundary of the concept of competence by formulating dimensions. The outside-in approach reduces the boundary by clarifying the relationships with related terms. The underlying assumption is that the meaning of competence is different from the meaning of related terms such as performance or ability, otherwise the term competence would be redundant (cf. Ockham's razor). Thus, competence is assumed to have a meaning of its own, and it is important to use the word competence properly and not to confuse it with related terms. Here, the keyword is "*terminological hygiene".*

The inside-out approach is a method to clarify the relationships and distinctions between competence and related terms, in order to use them appropriately and carefully. For example, a result from this terminological exercise may be that the term "qualification" appears to be much more appropriate than "competence". Or one may choose to incorporate the term knowledge in a definition of competence. But like in the inside-out approach, these choices alter the dynamic boundary of competence, this time from the outside (see Figure 2.1). For example, incorporating the term "knowledge" in a competence definition means that the boundary will extend as a result of absorbing knowledge as being part of competence.

The problem is how to investigate the differences and relationships between competence and related terms. Comparing definitions is only possible when competence is defined, which is the central problem in this article. Moreover, definitions of related terms possibly generate the same problem, that is, there being no consensus about the definition of a construct. Because of these considerations, in this article it is out of place to compare terms by focusing on their definitions. Rather, this article adopts an alternative method for comparing terms, regardless of their definition (Blokhuis, 2000; Blokhuis & Onstenk, in press). Here, competence is repeatedly compared with one related term at a time (e.g., competence – performance, competence – qualification), while using concrete examples. By using these concrete examples the focus is on the *use* of terms rather than on their definition. The possibility or impossibility of applying different terms to concrete examples unravels the underlying assumptions with respect to those terms. As a consequence, terminological hygiene will be facilitated.

Now which terms are related to competence? A quick review of competence literature produces already an extensive yet incomplete list: knowledge, skills, attitudes, acting, behavior, (effective) performance, expertise, profession, expertise, roles, tasks, context, qualification, collaboration, insights, ability, capability, meta-cognition, reflection, and so forth. In this section, competence is being compared with a few related terms: performance, qualification, capability, ability, knowledge, skill, attitudes, and finally the term expertise. The comparison process is being guided by three concrete examples: a mother, a painter and a salesman. In addition, differences in applying terms to the concrete examples are illustrated with literature, in order to deepen the discussion.

1. Competence versus performance.

Are competence and performance the same thing, using the concrete examples of a mother, a painter and a salesman? At first glance, there is no difference between competence and performance, regarding these three examples. But when looking closer, competence only applies to the examples when the result is at least effective. For example, painting a wall and leaving some parts untouched or making strokes on the window will not be regarded as competence. In this way, performance covers competence: competence is performance that is at least effective, that is, with respect to the three examples. Another intuitive difference between competence and performance is that performance is closely related to an observable, objective result, while competence seems to refer more to personal abilities that underlie this result.

Chomsky (1957, 1965) distinguishes performance from competence in a similar way. In his theory of linguistics, he argues that humans have *linguistic competence*, a deep structural patterning that enables the individual to generate new sentences constantly. Linguistic competence is the internalized knowledge of language and its rules that fully fluent speakers of a language have – an ideal knowledge. On the other hand, *linguistic performance* is the actual language behavior that a speaker generates. Linguistic performance shows imperfections, such as errors, pauses and irregularities, a kind of contamination of linguistic competence. Because of this, Chomsky considers linguistic competence as a purer basis for understanding linguistic knowledge. However, linguistic performance cannot be thrown out, for it is the only way to communicate competence. This view is clearly expressed by Gonzi, Hager and Athanasou (1993): "Performance is what is directly observable, whereas competence is not directly observable, rather it is inferred from performance." (p. 6).

2. Competence versus qualification.

Which term would you use to refer to a mother, a painter and a salesman: competence or qualification? Quickly, the term "qualification" does not seem appropriate to describe a mother, irrespectively of her being a good mother or a bad mother. On the other hand, the word "competence" is applicable. Thus, competent persons are not necessarily qualified. With respect to a painter and a salesman, both terms are useful. Qualification is associated with (vocational) standards, certificates and diplomas. It is some sort of an objective guarantee that a person has proven to have at least the minimal requirements to do a good job. Thus, in an ideal situation a qualified person is always competent. But one could imagine situations in which a qualified person does not seem to be competent.

There are definitions of competence which incorporate qualifications. For example Short (1984) argues that before a person can be judged as a competent teacher or manager, there needs to be agreement on a particular view of what it is to be a teacher or manager, what will be the scope of any statement of competence, what criteria will be used and what will be regarded as sufficient evidence. In his view, competence is a normative concept rather than a descriptive concept. According to Ellström (1998), "[qualification is] the competence that is actually required by the work task, or is implicitly or explicitly prescribed by the employer."(p. 41). Here, qualification is a sub-area of competence. Also, in the educational field competence has been connected to qualification. Competence is often operationalised in educational profiles, which are partly or entirely derived from vocational qualifications (e.g., Klarus, 1998; Verreck & Schlusmans, 1998).

3. Competence versus capability and ability.

Competence, capability and ability all seem to be applicable to the examples of a mother, a painter and a salesman. All three refer to intrinsic features necessary to get something adequately done. The relationship between competence, capability and ability seems to be closer than the relationship between competence, performance and qualification. Perhaps there is a small difference in the overt manifestation of competence and capability. Capability could refer to personal features that are not necessarily used, or that the owner is not even aware of.. Competence, on the other hand, seems to be related to personal features that are required in order to perform a particular activity. The performer may already possess these features, or may acquire them through training. The close resemblance between competence and capability is also illustrated by Eraut (1994), who uses the term capability to refer to concepts such as knowledge, skills and attitudes. These are often associated with competence.

4. Competence versus knowledge, skills and attitudes.

Are the terms knowledge, skills and attitudes applicable to a mother, a painter and a salesman? The answer seems to be yes. Additionally, a competent mother, painter and salesman are very likely to have sufficient knowledge and skills. With respect to attitudes, it is harder to say whether it contributes to competence or not. Thus, competence may enclose knowledge, skills and perhaps attitudes. Intuitively, skills and competence have a greater resemblance than knowledge and competence. Skills refer to actually doing something, while knowledge is a more intrinsic feature. One might conclude that competence is more strongly extrinsically than intrinsically oriented. In practice, competence definitions often refer to acting. A possible explanation is that acting is much more easy to assess and to describe than a "hidden" but yet unexpressed competence, as in Chomsky's linguistic competence.

In competence literature and in practical situations, a cluster of knowledge, skills and attitudes is often being used to define competence (e.g., Gonzi, Hager, & Athanasou, 1993; Parry, 1996). In this way, the comparison with competence is on a somewhat different level than the former constructs. Performance, qualification, capability and ability are horizontally compared to competence, whereas knowledge, skills and attitudes are judged as possible constituent elements of competence.

When competence is defined in terms of knowledge, skills and attitudes, do these three features together make a person competent? Here, meta-cognition is introduced as a possible addition to knowledge, skills and attitudes. *Meta-cognition* is a higher-order skill, referring to awareness and monitoring of one's own cognitive state or condition. It is the ability to reflect on our own cognitive condition, to assess how successfully our own memory and thought processes are operating (Ashcraft, 1994). Regarding knowledge, skills and attitudes meta-cognition could also refer to *allocation*: setting in knowledge, skills and attitude at the right moment, in an economical way. Wood and Power (1987) have a similar view: "[competence] rests on an integrated deep structure ("understanding") and on the general ability to co-ordinate appropriate internal cognitive, affective and other resources necessary for successful adaptation." (p. 414). In contrast, there are approaches in which competence does not contain knowledge, skills, attitudes or meta-cognition, but is something different (e.g., the chain model of competence, Derous, 2000). But this approach is not common. Also, subdividing competence in knowledge, skills and attitudes raises questions about the way they are interrelated.

5. Competence versus expertise

When the terms competence and expertise are being applied to the examples of a mother, a painter and a salesman, they both seem to be appropriate. However, a distinction appears when the examples are being formulated more specifically. For example, take the average number of cars a salesman sells each year. For a salesman that sells an average number of cars the term "competence" seems to be more appropriate than "expertise". In contrast, for a salesman selling the highest number of cars month after month the label "expertise" would be preferred, or alternatively, "highly competent". This intuitive difference is supported by Herling (2000), who states that competence refers to minimal efficiency whereas expertise refers to optimal efficiency.

The differences between competence and expertise remind at the discussion about "levels of competence versus competence as a level". Some authors think of a competent person as someone who is in between a novice and an expert (e.g., Dreyfus & Dreyfus, 1986; Eraut, 1994; Fuller, 1970). Here, the top salesman in the example would be labeled as an expert. In contrast, other authors favor a graded view of competence, ranging from low competence to high competence (e.g., Parry, 1996). They would call a top salesman highly competent. To increase the terminological confusion, Thijssen (1998) would use the words "excellent performance" to describe a top salesman, although he refers to a high level of competence as well.

Despite the little differences between competence and expertise it may be clear that they are closely related. This is clearly expressed in an expression of Chi, Glaser and Farr (1988) in their well-known work on the nature of expertise, where they combine the two terms into the single expression of "highly competent expert performance" (p. xvi).

2.4.3 Defining competence

We have seen that the inside-out approach supports people who define competence in clarifying their underlying conceptions an assumptions, and that it may provide clues for incorporating aspects of competence that were not identified before. Additionally, the outside-in approach is a method to carefully select appropriate terms for a competence definition.

The outside-in approach may be used in three steps. First, a relevant example should be selected. This may be a person or a task, like the examples used above. For example, when a competence definition is being constructed for developing the competences of managers, a relevant example may be a manager. It is important to choose an example that matches the goal of the competence definition. That is, when the goal is to develop the competences of managers in order to make them outstanding, one could select as an example an outstanding manager. Second, a list of possibly relevant terms should be constructed, for example in a brainstorm session. Here, people can come up with terms that they think should be included in a competence definition, or terms that are thought to be closely connected to competence somehow. Third, the example (or the examples) can be used in determining which terms are best applicable. For example, a question may be: Which term characterizes an outstanding manager best: competence or expertise? The application of terms to an example give clues about their underlying meaning and makes people aware of differences between related terms. As in the case of competence and expertise, people may decide to use expertise instead of competence, or they may favor the expression of high competence. Conclusively, like the inside-out approach, using the outside-in approach is a matter of making choices and of making clear underlying assumptions. The result of the outside-in approach is that terms will be chosen and used more carefully. This is very important, given the terminological confusion that goes with competence.

The final step is to define competence. Both the inside-out approach and the outside-in approach of competence have provided the ingredients for this definition. Metaphorically, the shape of the boundary of competence has been altered by stressing certain dimensions or related terms. Now, the ingredients have to be put together in one coherent definition. This final step is the most difficult one. The definitional choices that are being made here depend on all earlier decisions. Here is the challenge to combine all conceptual and terminological thinking. There is a possibility that some inconsistencies will appear, or that previous discussions about the constructivist variables, the inside-out approach and the outside-in approach are being reopened. In this respect, defining competence in a viable way may be considered as a process of increasing awareness, both conceptually as well as terminologically. The boundary approach of competence supports this process both by providing conceptual and terminological clues, and by visualizing the changes in the concept of competence as a result of conceptual and terminological considerations.

2.5 Conclusion and discussion

What is competence, going back to the initial question of this article? The constructivist answer is that there are several answers. Competence definitions are not being valued against the degree in which they are true, but against the degree in which they are viable. This article states that the viability of a competence definition increases when the first step in defining competence is the analysis of people, goal and context. Regarding people, the representations of and opinions about competence that people who construct a competence definition have should be explained. This is an important process since representations, opinions and underlying assumptions are likely to differ dramatically among individuals. In addition, the goal of the competence definition (or competence project) should be made clear in order to construct a suitable and useful definition. Finally, it should be clear in which context the competence definition is going to be used, and who the intended users of the definition are.

Additionally, this article proposes a boundary approach of competence, which supports people in thinking about the concept of competence and defining it in a constructivist way. It is both a visual and conceptual aid, representing the concept of competence as an amoeba-like form. It guides people in thinking about the concept of competence by drawing attention to dimensions of competence. Also, it helps people in using proper terms by introducing a method for comparing competence and related terms.

A constructed competence definition may need to be changed when the situation changes, that is, when the variables people, goal or context change. However, an important message of this article is to avoid continuously revising a competence definition or to wonder whether the definition is true. A consequence of constructing a competence definition is that it may differ from others. It is important to stick to the constructed definition, instead of revising the constructed definition over and over again in an (objectivist) search for the best competence definition. This is an expensive and time-wasting process. As soon as a competence definition has been constructed, one should proceed to other activities, such as using the definition of competence in building a HRD program.

Concluding, this article provided actual clues for constructing a viable competence definition. Additionally, the boundary approach of competence is a first step to the development of a sound theoretical framework for competence. It may be of great interest to study the effectiveness and applicability of the three constructivist variables people, goal and context, as well as the boundary approach of competence. Given the importance of the concept of competence in HRD as well as in education, the boundary approach of competence may be a meaningful instrument for project teams to cooperate successfully on competency development of individuals and organizations.

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3

Determining and describing curriculum content: bottlenecks and solutions[3]

Abstract. This article identifies bottlenecks that curriculum design teams encounter in determining and describing curriculum content. One questionnaire study and two case studies are reported. The key concept in the three studies is *competence*, which recently became an often-used term to describe curriculum content. Participants were 15 persons with experience in determining and describing either curriculum content or a particular professional domain in terms of competencies, and two heterogeneous project teams that were constructing a competence map, consisting of nine and four persons respectively. Data were gathered by means of a framework describing four problem areas in determining and describing curriculum content as encountered in literature: conceptual, procedural, interpersonal, and organizational. Instruments used in collecting data were a questionnaire and an observation form. Results indicate two types of bottlenecks: *conceptual* bottlenecks, dealing with the ambiguous meaning of competence; and *procedural* bottlenecks, dealing with a lack of methods for describing and ordering competencies. Solutions in terms of instructional design tools are proposed for overcoming these bottlenecks.

[3] This chapter is submitted as: Stoof, A., Martens, R. L., & Van Merriënboer, J. J. G. (2004). *Determining and describing curriculum content: bottlenecks and solutions*. Manuscript submitted for publication.

3.1 Introduction

"Everybody seems to know what schools should teach. […] Whether collective or individual, [these] views of the curriculum inevitably vary depending upon the specific value orientations that underlie them. Should a curriculum emphasize the acquisition of factual knowledge, or the solving of societal problems, or the development and stimulation of individual talents? […] Seldom is consensus easily achieved on such basic questions about what the curriculum should be" (Marsh & Willis, 1995, p. 5).

In curriculum design, one of the essential and first phases concerns the determination and description of curriculum content. While the analysis of desired content is a difficult process, it is yet a phase that is often neglected in the field of instructional design. This can be illustrated by analysing available computer-based design tools that help designers or design teams to perform one or more of the activities that can be organized according to the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). Most design tools aim at development, some aim at design and implementation, but almost none aim at evaluation or analysis, including the analysis of curriculum content (van Merriënboer & Martens, 2002). The goal of this article is to identify and analyse bottlenecks that design teams encounter in the process of determining and describing curriculum content, and then to propose possible solutions in terms of supportive instructional design tools.

In studying the process of determining and describing curriculum content, one cannot avoid the issue of terminological confusion. Traditionally, central questions that have to do with the analysis of the curriculum content are: What do students have to learn? What should be the learning outcomes of an educational program? What characterizes a professional in a particular area? Which demands does society put on employees? In answering these and related questions, many terms have been introduced to the educational vocabulary but also disappeared from it. Barnett (1994) refers to the "new vocabulary" and the "lost vocabulary". He argues, "…The new vocabulary … is a sign that the modern society is reaching for other definitions of knowledge and reasoning. Notions of skill, vocationalism, transferability, competence, outcomes, experiential learning, capability and enterprise, when taken together, are indications that traditional definitions of knowledge are felt to be inadequate for meeting the systems-wide problems faced by contemporary society" (p. 71). Thus, the process of analysing curriculum content is characterized by the use of a certain terminology, being a product of a changing society and changing conceptions of knowledge.

What then are the current problems and needs of society, and in particular of the professional environment for which students needs to be prepared? For most jobs, those environments are increasingly complex, knowledge intensive and dynamic. They ask for employees who are well educated, versatile and able to maintain their personal knowledge and skills (Bastiaens & Martens, 2000; Cluitmans, 2002; Mulcahy, 2000; Reiser, 2001; Schlusmans, Slotman, Nagtegaal, & Kinkhorst, 1999). In adapting to these needs, there is a strong movement in education towards a variety of popular educational approaches, such as authentic learning, collaborative learning, self-regulated learning, experiential learning, work-based learning, lifelong learning, problem-based learning, competence-based learning and open learning (Bourner, Katz, & Watson, 2000, Simons, van der Linden, & Duffy, 2000). This great variety of labels illustrates the evolving new vocabulary as well.

In this article, the term *competence* plays a central role since defining curriculum content in terms of competencies is rather popular in for example the USA and the UK (e.g., Barnett, 1994); Australia and New Zealand (e.g., Mulcahy, 2000), and the Netherlands (e.g., Stoof, Martens, van Merriënboer, & Bastiaens, 2002). There is a lot of discussion about the meaning of competence. Sometimes competence is defined as "a cluster of knowledge, skills and attitudes", but there are many other definitions. An in-depth analysis of this issue has been reported by Stoof, Martens, van Merriënboer and Bastiaens (2002). To summarize, competence definitions differ because of the different situations in which they are constructed. Analysis of the situation in terms of people, context and goal may help people in constructing a viable competence definition. The defining process may be supported by the so-called *boundary approach*, in which people determine their position on certain dimensions of competence (e.g., specific versus general competence, individual versus distributed competence), and explicate the differences between competence and related terms (e.g., performance, qualification, expertise).

In competence-based curricula, the overview of competencies that must be acquired by students is sometimes referred to as a *competence map* (Schlusmans, Slotman, Nagtegaal, & Kinkhorst, 1999). Together with other documents such as the educational plan and implementation plan, a competence map is one of the core documents in competence-based education (de Bie, 2003). Typically, competence maps consist of three parts: competence descriptions, a competence figure, and general information on the map. *Competence descriptions* contain detailed information of competencies, such as related roles or tasks, levels, relationships with other competencies and practical examples. Competence descriptions are the basis for curriculum design. A *competence figure* summarizes the most important information of the competence descriptions in a graphical figure, such as a hierarchical tree structure, a *n*-dimensional matrix, a circle diagram, or simply a list with a few headings. It provides an overall impression and serves as the "face" of the competence map. *General information* concerns the goal of the competence map, the domain, the competence definition, and other relevant information. This information is necessary for understanding a particular competence map, since competence maps differ strongly on these aspects.

In constructing a competence map, many stakeholders are involved such as teachers, curriculum designers, educational managers, branch representatives, public bodies and governmental organizations (Kessels, 1999). Highly diverse types of information must be taken into account by the design team, such as societal and technological trends, branch information, demands of business organizations, guidelines from the government, new insights into learning and instruction, curricula of competing educational institutes, and, last but not least, the content of the existing curriculum. Purves (1975) metaphorically refers to these elements as "the pieces of the curriculum game". In constructing a competence map, the design team essentially tries to collect and assemble all relevant pieces of information while using the competence map as an external representation to support communication and structuring.

To conclude, the construction of competence maps may be designated as an extremely complex task, for two reasons. On the one hand, the collection and assemblage of the "curriculum pieces" requires complex cognitive thinking, such as categorization, abstraction and representation. People who make a competence map have to select relevant pieces of information, they have to group and regroup this information into coherent competencies, they have to relate competencies to each other, they have to describe competencies in an understandable and comprehensive manner and finally they have to organize competencies in a visual summary. On the other hand, the construction of competence maps is further complicated because of the involvement of many stakeholders. The "pieces of the curriculum game" and their relative impact on the construction process may not be the same for all stakeholders. For example, where branch representatives may focus on branch information as the core ingredients of a competence map, teachers may focus on and even defend their own area of expertise, their "territory". Agendas and targets of stakeholders may be different as well. Thus, in addition to the complex nature of the task from a cognitive point of view, many perspectives and interests have to be dealt with. This requires high-level communication and excellent project leadership, which may not be at hand all the time.

The first step towards the development of supportive guidelines or tools for determining and describing curriculum content is to thoroughly analyse the complex processes lying behind. The main questions in this article are: (1) What are the main bottlenecks that design teams encounter in determining and describing curriculum content, and (2) What kind of supportive tools may be developed for overcoming these bottlenecks? The relevance of these questions goes beyond the issue of competence and competence maps. Identifying bottlenecks and proposing solutions with respect to the construction of competence maps is a first step towards identifying bottlenecks and proposing solutions for the process of determining and describing curriculum content in general, regardless the terminology that is used.

In this article, bottlenecks in constructing a competence map are placed into four problem areas as encountered in literature: conceptual, procedural, interpersonal, and organizational. The *conceptual* problem area concerns the unclear meaning of competence (e.g., Bennett, Dunne, & Carré, 2000; van Merriënboer, van der Klink, & Hendriks, 2002; Pilot, 2000; van der Klink & Boon, 2003). As reported by Stoof, Martens, van Merriënboer and Bastiaens (2002), people who work with the concept of competence frequently have difficulties with defining the concept. A related problem is the lack of clarity of the educational approach lying behind. This problem is mainly observed in competence projects that lack a clear, shared understanding of competence-based education.

The *procedural* problem area concerns the methods that are used by the design team to construct a competence map (Mulcahy, 2000; Pilot, 2000; Schlusmans, Slotman, Nagtegaal, & Kinkhorst, 1999; Verreck & de Vries, 2000). Similar to the lack of a commonly agreed definition of competence, there is also no standard for constructing a competence map. For example, methods differ in the way in which competencies are identified, described, interrelated to each other, and synthesized into one textual or visual representation. Curriculum design teams have great difficulties with determining how to perform these activities best.

The *interpersonal* problem area concerns the communication processes in the design team that constructs a competence map. Members of the design team may—and, actually, should—have divergent interests, backgrounds, and expertise (Mulcahy, 2000; Pilot, 2000; Stoof, Martens, van Merriënboer, & Bastiaens, 2002). Miscommunications may be a direct result of these differences. The risk of mutual misunderstandings may further increase because of the elusiveness of the concept of competence. People have different conceptualisations of competence. A design team may discuss the value of a particular method for analysing competencies, without being fully aware that person A means knowledge, skills, and attitudes when using the word competence; person B means observable behaviour, and person C does not have a clear conceptualisation of competence at all.

The fourth, *organizational* problem area finally refers to factors such as lack of available and appropriate members to participate in the curriculum design team; lack of time, money or other means; bad project management, and so forth (de Bie, 2003; Verreck & de Vries, 2000). Of course, such problems are not exclusive for curriculum design and may appear in other projects as well. Nevertheless, these problems may seriously hinder the task of determining and describing curriculum content. The non-existence of major organizational problems is a pre-condition for a successful competence project.

In the forthcoming studies, the four problem areas were used to systematically gather data on bottlenecks in constructing competence maps. The goal is to assess to what extent and in what form the problem areas as derived from literature occur when people actually make competence maps. The goal is to gain more insight in the bottlenecks in this process and to come to detailed bottleneck descriptions that can be used as a basis for developing tools or guidelines for determining and describing curriculum content. Three studies have been conducted: one questionnaire study and two case studies.

3.2 Study 1: Questionnaire Study

This first study aims to identify the bottlenecks that curriculum team members encounter in the process of constructing a competence map. The goal is to gather information about the occurrence and impact of the four previously defined problem areas and to further refine them where necessary.

3.2.1 Method

Participants

Initially, 47 potential participants with experience in determining and describing either curriculum content or a particular professional domain in terms of competencies were selected and addressed. A participant was only selected if "proof" of relevant experience existed in the form of reports, articles, or presentations. The final number of selected participants is 15 (i.e., 32%). The majority of the participants works within an educational context (87%) or has a background in education (73%). Most participants have a job as an innovation consultant or educational project manager.

Materials

The questionnaire contains five questions, four of which are directly related to the four problem areas described above. In addition, a fifth question covers problems that do not fit into the predefined problem areas, bearing in mind that one of the goals of this study is to refine problem areas in determining and describing curriculum content. All questions are closed (yes; no; I do not know). For *yes*-answers, participants are asked to give a more elaborate comment on their response. The questionnaire was tested to validate the questions before its use in the actual study. The questions are:

1. During the construction process of the competence map, did any problems occur that are related to the *conceptual* meaning of the word "competence"?

2. During the construction process of the competence map, did any problems occur that are related to the *procedural* method or approach that was used to construct the competence map?

3. During the construction process of the competence map, did any problems occur that are related to *interpersonal* communication between curriculum team members who were constructing the competence map?

4. During the construction process of the competence map, did any problems occur that are related to *organizational* factors such as lack of time or availability of appropriate team members?

5. During the construction process of the competence map, did any additional problems occur that have not been described in questions 1 to 4?

Procedure

The questionnaire was sent to the participants by email, with an accompanying letter describing the research project and the target group (i.e., people having experience with the construction of a competence map). Responses could be given either by e-mail or post.

Analysis method

The analysis of the comments for the *yes*-answers is based on a method used in grounded theory (Glaser & Strauss, 1967; Strauss & Corbin, 1990), according to which qualitative data are repeatedly analysed in order to develop an inclusive description. The method contains four steps: (1) developing a label system, (2) coding the given comments by marking relevant labels, (3) organizing the labels into categories, and (4) calculating the relative number of marked labels per category. In the first step, raters A and B (i.e., the first and the second author of this article) developed a label system. It was built through a cyclic process: the original comments were described in concise labels that, in turn, were compared with the comments. For each of the five questions, this process was repeated until a comprehensive set of labels had been developed.

In the second step, rater A and an independent rater C used the label system to code the comments given by the participants. Each comment was compared to the labels of the relevant system and a label was marked when it neatly matched the comment. For each comment, one or more labels could be marked. After marking the labels, rater C was asked to estimate the overlap between the marked labels and the original comments, to make sure that no important information disappeared by the translation of comments into marked labels.

In the third step, the labels were reorganized into main categories by using a method that borrows from the card sort technique (e.g., Shadbolt & Burton, 1995). Each of the labels was written on a separate card. These cards had to be organized into five stacks that could contain different amounts of cards. Then, each stack was given a category name and a short description (i.e., the dimensions that were conceptually used to sort the cards). This process was individually performed by raters A, B, and C. Subsequently, categories that were comparably named by the three raters, became the main categories of a system that could account for all comments. In addition, the composition of the stacks was compared. A card, which is an original label from step one, was classified as a member of one of the categories *only* when at least two of the raters had placed the card in the same stack. In this way, an improved category system was developed with well-elaborated categories, each containing a limited number of the original labels from step one. In the fourth step, finally, the relative number of marked labels was calculated per category.

3.2.2 Results

Question 1, concerning conceptual problems, was answered by 14 of the 15 participants: 64 % (n = 9) indicated to have *conceptual* problems and 36 % indicated no problems. Question 2, concerning *procedural* problems, was also answered by 14 participants: 50 % (n = 7) indicated to have procedural problems; 43 % indicated no problems, and 7 % did not know. Question 3, concerning *interpersonal* group problems, was also answered by 14 participants: 64 % (n = 9) indicated to have problems with the group process; 29 % indicated no problems, and 7 % did not know. Question 4, concerning *organizational* problems, was answered by all 15 participants: 33 % (n = 5) indicated to have organizational problems; 60 % indicated no problems, and 7 % did not know. Question 5, concerning all other problems, was answered by 13 participants: 46 % (n = 6) indicated to have additional problems; 31 % indicated no problems, and 23 % did not know. In total, 36 *yes*-answers were given.

The 36 *yes*-answers were accompanied by the same number of comments, which have been qualitatively analysed. In step one of the analysis, a label system was developed for each of the five questions, containing 7, 7, 8, 4 and 6 labels respectively. These 32 labels were yet highly specific, staying close to the original comments. There appeared to be much overlap between the five label systems, indicating that very similar problems were described in comments for different questions. For example, problems with formulating competencies were not only found in comments on question 1 but also in comments on questions 2, 3 and 5. In the second step, the 32 labels were used to code all the 36 comments, resulting in 51 reliable marked labels (Cohen's Kappa = .94; note that it is possible to mark more than one label for the same comment). Rater C estimated that the overlap between the original comments and the marked labels is 90 % - indicating only a small loss of information. In the third step, the 32 labels from step 1 were re-arranged into five categories: (1) meaning of competence, (2) method, (3) group processes, (4) consequences, and (5) a rest category. Each category only contains the labels that were appointed to this category by at least two of the three raters. In the fourth and final step, the relative number of marked labels per category was calculated.

Table 3.1 summarizes the results of the qualitative analysis of the 36 comments. The column on the left presents the five main categories from step 3, with illustrative labels that were appointed to these categories by at least two of the three raters. The columns in the middle (question 1, question 2, etc.) show for each of the five questions from the questionnaire, the classification of the comments over the main categories. For example, the nine comments for question 1 (i.e., the conceptual problem area) are classified in the category “meaning of competence” eight times and in the category “consequences” two times. This indicates that one of the comments has been classified in *both* categories. The right column shows the relative number of marked labels per category. For example, 14 of the total of 42 marked labels (33 %) were in the category “meaning of competence”.

3.2.3 Discussion

Both the answers to question 1 and the analysis of the related comments indicate that conceptual problems with the meaning of competence are the number-one problem area in constructing a competence map. Curriculum team members have large difficulties with defining and describing competencies and with distinguishing the concept “competence” from related terms such as skills, performance, expertise and so forth. Based on Stoof, Martens, van Merriënboer and Bastiaens (2002) we introduced conceptual issues as one of the possible problem areas, and both the quantitative and qualitative results confirm that conceptual issues are a bottleneck indeed. In the closed part of the questionnaire, two-third of the participants reported problems with the concept of competence. The same problem is regularly described in the comments on question 1 as well as in comments for other questions (especially questions 2 and 3).

Two other areas show distinctive results: procedural and interpersonal problems. For question 2, concerning the procedure for developing a competence map, half of the participants indicated to have problems. The comments are for one-third directly related to the working method, but also to all other categories. A useful working method should be designed in such a way that it helps to clarify the concept of competence and structures task-related group processes. For question 3, concerning interpersonal problems with communication, two-third of the respondents reported problems. A closer inspection of the comments indicates that two-third of the comments actually refers to other problems, such as the meaning of competence and the method (see Table 3.1). Nevertheless, one-third of the comments is related to group processes and comments for other problem areas (e.g., procedural, organizational) are also frequently related to group processes. While interpersonal communication may not be a distinctive problem area in itself, task-related group processes in the curriculum design team seem to be

Table 3.1: Classification of comments into five main categories: (1) meaning of competence, (2) method, (3) group processes, (4) consequences, and (5) a rest category.

Main categories and illustrative labels	Classification of comments in categories	
	Question 1 (conceptual, 9 comments)	Question 2 (procedural, 7 comments)
1. Meaning of competence • problems with defining and describing competences • it is unclear what competence is • there is a unclear difference between competence and related terms such as knowledge, ability, task, profession, learning goals etc. • the borders of competence are unclear • the term competence is unclear and prone to various explanations • opinions about competence differ • competences provide no hold	8	3
2. Method • there is no method or the existing method is not appropriate for the project • problems with the structure of a competence map or with organizing competences in a clear framework • structure, representation and functions are not clear in advance • little knowledge about competences among group members	0	4
3. Group Processes • problems because many stakeholders are involved • problems with tuning people who construct the competence map • usual problems: lack of time, lack of available and appropriate team members • different opinions • teachers do not cooperate or have too much influence • bad project leader or change of project leader during process • problems because many persons have to be questioned	0	2
4. Consequences • unclear meaning of competence-based education • a changing view on education • difficulties with implementation/use of competence map in existing curriculum • problems with acceptation and recognition	2	2
5. Rest Category	0	1

Table 3.1 (cont.)

Classification of comments in categories			Relative # marked labels
Question 3 (interpersonal, 9 comments)	Question 4 (organisational, 5 comments)	Question 5 (other, 6 comments)	
2	0	1	33 %
3	0	1	19 %
3	5	0	24 %
1	0	2	17 %
0	0	2	7 %

important. Possibly, guidelines for the composition of the team and setting up the work process may help to overcome these problems.

Results for the remaining problem areas do not add much to the analysis above. For question 4, concerning organizational issues, one-third of the participants reported problems but the analysis of the comments indicates that these are actually all related to the group process. For question 5, concerning all other problems, the analysis of comments indicates that they are more or less equally distributed over the different categories.

3.3 Study 2: Case Study Facility Management

The previous study collected, afterwards, experiences of curriculum team members who had been involved in different competence projects. In contrast, the present case study closely follows the process of constructing one competence map by one design team in order to deliver first-hand, ecologically valid information. It focuses on a competence project conducted in an institute for higher professional education (HPE) in the Netherlands. Again, the central research question aims to identify the main bottlenecks in determining and describing curriculum content.

3.3.1 Method

Participants

The institute for HPE involved, called Diedenoort, offers a four-year master's program in Facility Management. Besides this program, Diedenoort has two branches in consultancy and employability, which also operate in the domain of Facility Management. During a five-month period, a curriculum design team has been involved in the construction of a competence map. The goal of the project was to "determine and describe the new curriculum content in terms of competencies within the domain of Facility Management". This project was the first step in a larger curriculum reform process aiming to strengthen the link between the educational program and practical work in the field of facility management.

The director of the institute composed the design team. It consisted of the director himself, who also acted as chair, and eight other members: the manager of the consultancy branch, the manager of the educational program, the coordinator for internships, the coordinator of the educational program, three teachers, and one student who was in her final year of study.

Materials

An observation form and a questionnaire were used to gather data about the conceptual, procedural, interpersonal, and organizational problem areas.

The observation form was designed to rate 19 predefined problems, being subcategories of the original four main problem areas (see Table 3.2). They had been formulated by using the results of Study 1 and experiential data. All subcategories, except those in the organizational problem area, had to be rated on a 5-point Likert scale, ranging from (1) no problem or negligible problem to (5) a very large problem. The subcategories in the organizational problem area had to be rated on another 5-point Likert scale, ranging from (1) fully disagree to (5) fully agree. For each subcategory, the observation form provided opportunities to give examples or additional comments. In addition to the 19 subcategories, one subcategory was added for reporting all other problems.

The questionnaire contains 19 items identical to the items in the observation form. One open question was added, asking team members to describe what they thought was the most prominent problem in the project. In addition, six items were added to measure the influence of the observer on the group process and product, such as: "Without the involvement of the observer other choices would have been made within the project". Those items had to be scored on the Likert scale ranging from "fully disagree" (1) to "fully agree" (5).

Procedure

During the project, there were three physical meetings of approximately three hours each. In the third meeting, consensus had to be reached on a final draft of a competence map for the domain of Facility Management. Some weeks later, the competence map was presented in a workshop with external field experts, in order to gather additional information for adjusting the competence map. One observer attended each meeting, using the observation form to describe all problems that the design team encountered. During and immediately after each meeting, all subcategories were rated, except the last four subcategories that were rated only after the third meeting. The first meeting was also observed and rated by a second observer in order to validate the observation form (Cohen's Kappa .62). One month after the workshop, the curriculum team members filled out the questionnaire.

3.3.2 Results

The three meetings focused, in order, on (1) the definition of competence and a procedure that could be used for constructing the competence map, (2) a preliminary structure for the competence map and a first, rough description of competencies involved, and (3) a draft version of a detailed competence map. In between the meetings, the team members worked on the evolving structure of the competence map and on the analysis and description of competencies in the field of Facility Management. The competence map that was presented during the workshop with the field experts was not yet a final product, and has since been revised and updated several times. Therefore, the presented results only deal with the first phase of the competence project, that is, the phase of exploration, exchange of ideas, and tentative construction of a map.

Table 3.2 presents the results obtained from the observations and the questionnaire. For the observations, the mean, minimum and maximum scores refer to the ratings of the observer during the three meetings of the design team. The means represent a "process mean", indicating which items are most problematic over a total of three meetings. The minimum and maximum scores show the lowest and highest rating obtained in the three meetings. The observation results are used to corroborate the results from the questionnaire.

The questionnaire results in the right column of Table 3.2 show the difficulty of items according to the nine team members one month after the final meeting. Four items are rated by the team members as more than a moderate problem: (1) problems with describing and ordering competencies into a clear framework (M = 4.0); (2) confusion of concepts: competence and related terms are used and conceptualised in different ways (M = 3.56); (3) which steps to take in making a competence map (M = 3.56), and (4) the group did not work well with regard to the planning and quality of deliverables (M = 3.50). The results for the first two items are substantiated by the observation results, which also pointed out these items as particularly difficult. The influence of the presence of the observer on the group process and product as estimated by the team members was an acceptable 2.41, that is, between "disagree" and "neither disagree nor agree".

For the open question of the questionnaire, participants report the following main obstacles: (1) ordering and describing competencies (n = 4); (2) group composition, process and project management (n = 4); (3) the translation of a competence map into the curriculum (i.e., course contents) and the use of a competence map in general (n = 2), and (4) defining competencies and tuning definitions (n = 2). A remaining obstacle was identified during the observations, namely concerns about the "professional identity". This obstacle often appeared within the context of two items: ordering and describing competencies as well as the goal of competence based education. Questions arose such as: "what is Facility Management? what are Facilities?, and what should a Facility Manager be able to do?"

3.3.3 Discussion

The results of this study clearly indicate that problems with describing and ordering competencies into a clear framework form a main obstacle for curriculum design teams. This problem occurred throughout the entire design process and was recognized by both the team members themselves and the observer. From the observations, it became clear that these problems had strong practical implications: difficulties with constructing a framework (e.g., deciding between a hierarchical tree structure, a concept map, or a linear sequence), with choosing levels and dimensions, with linking competencies to each other, and so further. Another particularly important problem pertains to confusion in the design team about the meaning of competence and how to use it. This finding is in agreement with the results from Study 1.

Table 3.2: The mean and maximum observed scores for the observation form and the mean scores for the questionnaire (5-point scales) in Study 2.

Problem area	Item	Observation form			Questionnaire (*N*=9)		
		M	*Range*		*M*	*Range*	
			Min.	*Max.*		*Min.*	*Max.*
Conceptual[a]	Problems with the definition/demarcation of the term competence	2.00	1.00	3.00	3.33	2.00	5.00
	Problems with the surplus value of competence	1.00	1.00	1.00	2.67	1.00	4.00
	Problems with the goal of competence based education	2.33	1.00	3.00	3.33	2.00	5.00
Procedural[a]	What is a competence map and what does it look like?	1.33	1.00	2.00	3.44	2.00	5.00
	Which steps to take in making a competence map?	1.33	1.00	2.00	3.56	2.00	4.00
	Problems with describing/ordering competences in clear framework	4.67	4.00	5.00	4.00	2.00	5.00
Interpersonal[a]	Problems in reaching consensus: different interests and viewpoints	1.00	1.00	1.00	3.13	1.00	5.00
	Confusion: competence/related terms used in different ways	2.33	1.00	3.00	3.56	1.00	5.00
	Going round in circles: repeating the same discussion over and over	1.33	1.00	2.00	2.78	1.00	5.00
Organizational[b]	Bad project chair	1.00	1.00	1.00	2.13	1.00	3.00
	Unstructured group process	1.00	1.00	1.00	2.63	2.00	4.00
	Low motivation of group members	1.00	1.00	1.00	2.25	1.00	4.00
	Social tensions and disturbed relations	1.00	1.00	1.00	2.75	1.00	5.00
	Stubborn group members	1.33	1.00	2.00	2.75	1.00	5.00
	Negative influence of group process on the task (i.e., making a map)	1.00	1.00	1.00	2.50	1.00	4.00
	Group did not work well (planning and quality of deliverables)	2.00	2.00	2.00	3.50	2.00	5.00
	Group composition was not optimal	3.00	3.00	3.00	3.25	1.00	5.00
	Too little money and supporting means	1.00	1.00	1.00	2.63	2.00	4.00
	Too little time	2.00	2.00	2.00	2.88	1.00	4.00

[a] Scale ranges from 1 to 5 (no or negligible problem, small problem, moderate problem, large problem, very large problem).
[b] Scale ranges from 1 to 5 (fully disagree, disagree, neither disagree nor agree, agree, fully agree).

3.4 Study 3: Case Study Financial Business Management

In addition to the questionnaire study and the case study Facility Management, a second case study has been conducted. The goal of this study is to identify problems in determining and describing curriculum content in terms of competencies, but also to replicate the findings of the previous studies in a new context. In contrast to Study 2, this study focuses on a competence project with a national scope (i.e., the Netherlands). A National Committee initiated the project, which aimed at the construction of a professional and educational profile for most Dutch HPE institutes offering a master's program in Financial Business Management. A competence map is the basis of such a profile and describes a domain or profession in terms of typical tasks, responsibilities, competencies, and future developments as a basis for curriculum revision (Boon & van der Klink, 2001). In addition to the HPE institutes, other stakeholders were the Dutch HPE Council ("HBO-raad") as well as several branch representatives. The case study focuses on the work of the design team that was responsible for the major choices concerning the profile. It took the design team six months to develop the profile.

3.4.1 Method

Participants and materials

An external senior consultant, who also managed the entire project and had prior experience with managing comparable projects, chaired the design team. The team further consisted of three educational managers, representing three HPE institutes. All materials used to collect data are identical to those in Study 2.

Procedure

Over a period of six months, the design team had 12 physical meetings that took approximately two hours each. Shortly after the final meeting, the professional and educational profile constructed by the design team was presented to the National Committee. Six of the 12 meetings were observed: 1, 2, 3, 4, 6 and 8. The first complete version of the profile was discussed in meeting 8. As in Study 2, the observation form was used to gather data during and shortly after the meetings. The chair and the three team members filled out the questionnaire directly after meeting 8. During the whole process, there were regular meetings between the primary researcher and the chair of the design team, in order to gather additional qualitative data about the process and the problems that were observed or could be expected in the project.

3.4.2 Results

The professional and educational profile was built in a complex process of collecting and analysing givens about relevant competencies; communicating with stakeholders, and developing and using a framework of domain specific language, a competence definition, validation procedures, and so forth. The structure of the profile including its domain specific language was revised many times and continuously evolved throughout the project. Documented experiences from other, comparable competence projects were heavily used (e.g., Boon & van der Klink, 2001; Tilman, Pepels, & Kasper, 2000; Verreck & de Vries, 2000). The draft of the profile discussed in meeting 8 was already worked out very well. The revised concept, presented to the National Committee after the 12th meeting, received a lot of appreciation and compliments from the stakeholders. For a detailed description of the process and the resulting professional and educational profile, see Tilman, Stoof, Blokland, Thijssen and Dukker (2001).

Table 3.3 presents the results obtained from the observations and the questionnaire. For the observations, the mean and maximum scores refer to the ratings of the observer during six out of the twelve meetings. As in Study 2, the mean scores represent "process means" and the maximum scores represent the highest rating obtained in the six meetings. The observation results are used to steer the collection of additional qualitative data (e.g., in meetings with the chair of the design team) and to corroborate the results from the questionnaire.

The questionnaire results in the right column of Table 3.3 show the difficulty of items according to the four team members after the sixth observed meeting (i.e., meeting 8). Four items are rated by the team members as more than a moderate problem: (1) problems with the definition or demarcation of the term competence (M = 3.50); (2) problems with describing or ordering competencies into a clear framework (M = 3.25); (3) what is a competence map and what does it look like? (M = 2.75), and (4) the problem of going round in circles and repeating the same discussion over and over (M = 2.75). The results for the first two items are firmly substantiated by the observation results, which also pointed out these items as particularly difficult. The maximum score given by the observer for describing and ordering competencies into a clear framework is even 5, that is, the highest score possible (i.e., a very large problem). The influence of the presence of the observer on the group process and product as reported by the team members was 2.17, that is, between "disagree" and "neither disagree nor agree" for negatively formulated statements such as "without the involvement of the researcher other choices would have been made".

Table 3.3: The mean and maximum observed scores for the observation form and the mean scores for the questionnaire (5-point scales) in Study 3.

Problem area	Item	Observation form			Questionnaire (*N*=9)		
		M	*Range*		*M*	*Range*	
			Min.	*Max.*		*Min.*	*Max.*
Conceptual[a]	Problems with the definition/demarcation of the term competence	2.00	1.00	4.00	3.50	3.00	4.00
	Problems with the surplus value of competence	1.00	1.00	1.00	2.00	1.00	3.00
	Problems with the goal of competence based education	1.67	1.00	3.00	2.50	2.00	4.00
Procedural[a]	What is a competence map and what does it look like?	1.00	1.00	1.00	2.75	2.00	4.00
	Which steps to take in making a competence map?	1.17	1.00	2.00	2.25	1.00	3.00
	Problems with describing/ordering competences in clear framework	3.17	1.00	5.00	3.25	2.00	4.00
Interpersonal[a]	Problems in reaching consensus: different interests and viewpoints	1.00	1.00	1.00	2.25	1.00	4.00
	Confusion: competence/related terms used in different ways	1.33	1.00	2.00	2.50	2.00	4.00
	Going round in circles: repeating the same discussion over and over	1.00	1.00	1.00	2.75	2.00	3.00
Organizational[b]	Bad project chair	1.17	1.00	2.00	1.67	1.00	2.00
	Unstructured group process	1.00	1.00	1.00	1.25	1.00	2.00
	Low motivation of group members	1.00	1.00	1.00	1.00	1.00	1.00
	Social tensions and disturbed relations	1.00	1.00	1.00	1.00	1.00	1.00
	Stubborn group members	1.17	1.00	2.00	1.50	1.00	2.00
	Negative influence of group process on the task (i.e., making a map)	1.00	1.00	1.00	1.00	1.00	1.00
	Group did not work well (planning and quality of deliverables)	1.00	1.00	1.00	1.75	1.00	2.00
	Group composition was not optimal	2.00	2.00	2.00	1.50	1.00	2.00
	Too little money and supporting means	1.00	1.00	1.00	1.75	1.00	2.00
	Too little time	2.00	2.00	2.00	2.50	1.00	3.00

[a] Scale ranges from 1 to 5 (no or negligible problem, small problem, moderate problem, large problem, very large problem).
[b] Scale ranges from 1 to 5 (fully disagree, disagree, neither disagree nor agree, agree, fully agree).

On the open question of the questionnaire, the team members report the following two obstacles: (1) the design of a format or ordering principle for the competence map ($n = 2$), and (2) achieving commitment from the stakeholders ($n = 1$). Three remaining problems were revealed during the observations and in the regular, informal interviews with the chair of the design team. The first obstacle was also found in the previous study: the problem of professional identity. During the project, questions arose about the meaning of Financial Business Management and its range, about the characterization of a Financial

Business Manager, and even about the designation of Financial Business Management. Two additional, minor problems were related to imperfect communication with the stakeholders and the validation of the professional and educational profile.

3.4.3 Discussion

This study revealed two problems as particularly important. First, there is a clear problem with the definition and the demarcation of the term competence, a finding that replicates the main result from Study 1. Second, there is another pertinent problem with describing and ordering competencies into a clear framework, a finding that replicates the main result from Study 2. Overall, there is substantial overlap between the results of the three reported studies, which jointly point out some possible solutions for overcoming the bottlenecks. These general findings and potential solutions are discussed in the next section.

3.5 General discussion

Determining and describing curriculum content in a so-called competence map is a rather new and unexplored phenomenon, and the three explorative studies mainly yielded explorative results that provide ideas and starting points for further research in this important but neglected area. The three studies show a quite homogeneous pattern with regard to the four problem areas. The first *conceptual* problem area, regarding the meaning of competence, has been identified as a severe bottleneck in all three studies. In Study 1, conceptual problems with the meaning of competence were identified as the most important problem that curriculum team members had to face; in Study 3, problems with the definition and demarcation of competence and related terms was also found to be one of the largest problems. The results of Study 2 are less clear, but several items indicated the existence of conceptual problems. For instance, confusion in the design team about the term competence and related terms as well as mutual misunderstandings due to the use of those terms in different ways was common and found to be one of the largest problems.

The second *procedural* problem area, regarding the method for constructing a competence map, could also be recognized in all three studies. In Study 1, difficulties with finding a procedure for making a competence map were identified as the second largest problem. In Study 2, the lack of a procedure for describing and ordering competencies into a clear framework was even found to be the most urgent problem. And in addition, team members indicated that they felt insecure which steps to take during the construction of a competence map. And finally, in Study 3, problems with describing and ordering competencies into a clear framework were found to be the second largest problem (according to the observer, even the largest problem). The participants also indicated not to have a clear picture of what a competence map is and what it should look like.

The third *interpersonal* problem area, regarding the communication in the design team, yielded an interesting finding. At first sight, it seemed to be an important area because two-third of the participants in Study 1 reported it as problematic. However, an analysis of their comments revealed that those largely belonged to other categories, dealing with the meaning of competence and the method for the analysis of competencies. Possibly, communication problems are mainly an expression of problems in other areas. This interpretation was supported by the results of the case studies. As indicated before, the most important communication problem in Study 2 concerned mutual misunderstandings due to terminological confusion, that is, conceptual problems. In Study 3, the main interpersonal problems concerned repeating the same discussion over and over – which also indicates conceptual ambiguity. Concluding, interpersonal communication in the design team cannot be identified as a distinctive problem area.

The fourth *organizational* problem area, concerning traditional difficulties with time, money and project management, did not show up as particularly important. Only in Study 2, the team members indicated that the project planning and the quality of deliverables were somewhat problematic. Organizational issues played a minor role in Studies 1 and 3. Thus, there is no reason to believe that competence projects suffer more from organizational problems than other educational design projects of the same complexity.

Three additional bottlenecks have been identified as part of a fifth problem area. First, Study 1 revealed the importance of "consequences", that is, problems dealing with the question of how to use and implement a competence map, and how to translate it to learning tasks in the context of competence based education. Such use and implementation issues were also identified in Study 2 (as a reaction to the open question). Second, the interviews in both Study 2 and Study 3 indicated problems concerning professional identity. Curriculum design teams had great difficulties with defining and demarcating their domain. For example, in Study 2 questions were raised such as: "What is Facility Management? What does and does not belong to it? What is a Facility Manager?" In Study 3, even the name of the domain itself (Financial Business Management) was questioned. Finally, Study 3 revealed some difficulties with achieving commitment from the HPE institute and conducting the validation of the competence map.

The three reported studies share some shortcomings. First, they focused on the process instead of the products (e.g., the competence map and intermediate products) that were produced by the design team. It might be worthwhile to develop evaluation instruments for those products and to combine process and product measures. Second, an in-depth analysis of particular findings might have yielded more insight in the design process. For example, one-third of the participants in Study 1 did not report problems with the meaning of competence. It would be interesting to find out when dealing with the meaning of competence is experienced as a problem and why it is not. We suspect that the problem might be hidden, unrecognised, or mistakenly unattended. Third, the number of participants was limited. The studies were set up as explorative studies without experimental control, opting for a combination of ecological valid contexts and a combination of research methods, sometimes referred to as triangulation (Miles & Huberman, 1984). Clearly, future studies must also focus on produced output, conduct an in-depth analysis for particular process measures, use larger groups, and apply higher experimental control.

While future experimental studies are necessary, the three explorative studies reported in this article gave a picture of the main process layers that can be distinguished for a curriculum design team. When a team reconsiders curriculum content by using the concept of competence, it enters an elusive area and is confronted with educational philosophy, professional identity, and unfamiliar terminology for expressing ideas. Combined with the large consequences of such a project and the existence of many stakeholders, this puts a great demand on the team. At the first process layer, it is of critical importance that organizational issues are well settled and interpersonal communication within the team and between team members and other stakeholders is open and goal-directed. The second process layer concerns the construction of a clear view on competencies, competence based education, and professional identity. These difficult conceptual issues are central in any competence project. Especially the definition of competence determines almost the entire construction process of a competence map. The third process layer refers to determining and describing competencies into a clear framework. This step seems to be very difficult as well. On the one hand, team members know what they have to reach (i.e., a well-organized and properly formulated overview of curriculum content in terms of competencies); but on the other hand, there are insufficient methods available that meet requirements such as usability (e.g., avoid maps with too many competencies, use a framework that is easy to understand and work with), restrictedness (e.g., avoid maps that take different domains into account), and simplicity (e.g., avoid maps that distinguish knowledge, skills and attitudes for each competence).

When returning to the second question in this article: What kind of supportive tools may be developed for overcoming these bottlenecks?, we can conclude the following. It became clear from our studies that curriculum team members experience the task of determining and describing curriculum content in terms of competencies as highly complex. This complexity is further increased because the task is embedded in the rapidly changing field of education, having bottlenecks of its own (cf. Barnett, 1997; Dearing, 1999; Watts, 2000). In order to reduce complexity and to optimise the performance of curriculum design teams, the conceptual and procedural problems need to be tackled first. With regard to conceptual problems, it is *not* a solution to continue looking for a general acceptable definition of competence, which is often either too broad or too vague, but rather to look for flexible tools or approaches to come to a pragmatic description that is suited for the specific context in which the design team is operating. Examples of such approaches are described by Stoof, Martens, van Merriënboer and Bastiaens (2002) and van Merriënboer, van der Klink and Hendriks (2002).

With regard to the procedural problem area, there is a need for tools or approaches that help designers to organize their ideas, to analyse competencies, and to visualize and construct coherent competence maps. Procedures for the determination and description of competencies are, for example, provided by Boon en van der Klink (2001), Cluitmans (2002), de Bie (2003), and Fletcher (1997). It may further be of interest to incorporate techniques that support designers in reducing a vast amount of qualitative data, such as gathered by interviews or observations, together with domain experts into condensed descriptions of competencies. Such techniques may be found in the literature on qualitative data analysis (e.g., Miles & Huberman, 1984; Strauss & Corbin, 1990) and in the literature on knowledge elicitation and representation techniques (e.g., Shadbolt & Burton, 1995).

To increase the quality and effect of a supportive tool or procedure for determining and describing competencies, additional recommendations from the area of instructional design and curriculum design should be considered. First, the tool should be flexible and adaptive. Although this is recommended in general (Gustafson, 2002; van den Akker, 2003; van Merriënboer, & Martens, 2002), flexibility and adaptability is especially important when dealing with competencies and competence maps. People will not use a tool that does not meet their own ideas and needs. Second, a supportive tool should encourage the formation of a project team and the construction of a project plan as a starting point for the development procedure. It is strongly recommended to involve teachers in this project team (de Bie, 2003). In addition, it is recommended to incorporate other stakeholders in the project team as well, for example curriculum designers, educational managers, branch representatives, public bodies and governmental organizations (Kessels, 1999). In any case, stakeholders should be involved right from the beginning (van den Akker, 2003). Finally, a supportive tool should be suitable for novice as well as expert users (Gustafson, 2002).

To conclude, the development and evaluation of a supportive tool or procedure for determining and describing curriculum content is one of the challenges to instructional design and curriculum design. It is of great importance to pay attention to this neglected area, since a good description of the curriculum content is the basis for all further aspects of curriculum design.

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Part B: Tool development

Contents:

4

Web-based support for designing competence maps: design and formative evaluation[4]

Abstract. This article describes the design and formative evaluation of a web-based tool that supports curriculum developers in constructing competence maps. Competence maps describe final attainment levels of educational programs in terms of - interrelated - competencies. The central demands to the supportive tool were validity and practicality. Validity is grounded in the theoretical underpinnings of the tool, which describe the functionality of conceptual and procedural support, and the supportive aids that can be used to design such support. Practicality is fostered by an evolutionary prototyping approach, in which feedback from intended users and domain experts is collected throughout the development process. Formative evaluations of four prototypes were conducted. Measures of design, appeal, goal, content, confidence and relevance show that the tool is practical. An extensive description of the final tool is given from the perspective of the user, the curriculum developer, and the instructional designer.

[4] This chapter is submitted as: Stoof, A., Martens, R. L., & Van Merriënboer, J. J. G. (2004). *Web-based support for constructing competence maps: design and formative evaluation*. Manuscript submitted for publication.

4.1 Introduction

The concept of competence plays an important role in modern education. Institutes of middle and higher professional education and several universities in for example the USA, the UK and Australia regularly adopt the concept of competence as a means to develop new forms of education. Competence-based education may be regarded as an answer to societal changes. Jobs and working situations have become more dynamic and complex, thereby posing specific demands to employees (van der Klink & Boon, 2003). Competence is a concept that provides clues to think about these new requirements and to design curricula that take them into account. Characteristics of competence-based education that are often mentioned are a focus on authentic professional situations, tasks, and roles from which the learning content is derived; authentic assessment in the beginning, during and at the end of the learning process; integration of learning contents instead of fragmentation; the student as a planner of his or her own learning path, and the teacher as a coach (De Bie, 2003; Schlusmans, Slotman, Nagtegaal, & Kinkhorst, 1999).

In developing a competence-based curriculum, the first step is to identify and describe the final attainment levels of the curriculum content in terms of competencies. This is documented in a so-called *competence map*, which is one of the most important documents for developing competence-based education. Typically, a competence map is generated by a heterogeneous team that consists of knowledgeable persons such as curriculum designers, teachers, educational managers, practitioners, field experts, and branch representatives. The process in which a competence map is constructed is complex and difficult, as all processes of curriculum development and educational change are (De Bie, 2003; McKenney, Nieveen, & van den Akker, 2002).

Empirical research has shown that the process in which a competence map is made, is characterized by several bottlenecks (Stoof, Martens, & van Merriënboer, 2004a). A major bottleneck is struggling with the definition of competence and the difference between competence and related terms such as knowledge, skills, ability, and expertise. People do not know what competence means or how it should be defined. This problem has been reported in theoretical explorations of this topic as well (e.g., Stoof, Martens, & van Merriënboer, 2002; van Merriënboer, van der Klink, & Hendriks, 2002). Another major bottleneck concerns the procedure for constructing competence maps. Especially the lack of procedures for describing competencies and ordering them into a clear framework is a problem (see also de Bie, 2003).

A possible solution to overcome these bottlenecks is to support designers of competence maps with an instructional design tool that helps them to define the concept of competence and guides them through the development process. Such a tool is expected to lead to improved task performance, increased task-related knowledge, increased satisfaction, and increased internal consistency of the output (Gery, 1991; McKenney, Nieveen, & van den Akker, 2002; Stevens & Stevens, 1990). However, existing instructional design tools mainly focus on authoring, that is, the development or production of computer-based instruction. Thus far, very little attention has been paid to the issue of curriculum content analysis, in terms of competencies or otherwise (van Merriënboer & Martens, 2002).

Therefore, the presented study focuses on the design and formative evaluation of a supportive tool for constructing competence maps. The central research question is: What are the characteristics of a valid and practical tool that supports designers conceptually as well as procedurally in constructing a competence map? The *validity* of such a tool implies that it is based on state-of-the-art knowledge and that the various components of the tool are consistently linked to each other (van den Akker, 1999). That is, the tool should have a thorough theoretical basis and be internally consistent. The *practicality* of the supportive tool holds that users and other experts consider the tool as appealing and usable under normal conditions (van den Akker, 1999). In other words, the tool should be easy and pleasant to use, it should meet the needs and demands of the target group, and it should fit to the task of constructing competence maps.

This article is organized in six sections. The first two sections describe the theoretical underpinnings in which the validity of the tool is grounded. The first section concerns the functionality of the conceptual and procedural support, whereas the second section describes the different types of supportive aids that can be used for the technical design of such support. The next three sections focus on the design and evaluation of the tool as well as its practicality. The third section describes the design approach; the fourth section describes the methods for the formative evaluation of the tool, and the fifth section discusses the results of the formative evaluation. The final section is a general discussion, in which an extensive description of the final version of the tool is presented.

4.2 Conceptual and procedural support

The construction of competence maps is part of a larger process, which is described by Tilman and Stoof (2002). Figure 4.1 shows a slightly adjusted version of this process with the phases: initiation, construction, validation, and acknowledgement. In the initiation phase the user makes preparations for the construction of the competence map, by composing a project team and writing a project plan. In the construction phase, the competence map is developed. This step contains the conceptual and procedural support. Subsequently, the competence map is validated. If necessary, the competence map has to be adjusted and validated again, which is depicted by the arrows in Figure 4.1. In the final phase, the competence map is formally acknowledged by all stakeholders, after which the competence map is ready for implementation in the curriculum. This section describes the functionality of the support that designers need to overcome the conceptual and procedural problems they encounter in the second phase of the whole process.

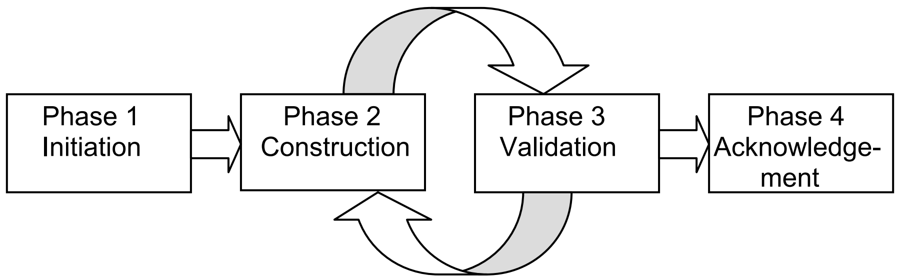

Figure 4.1: Phases in constructing competence maps.

4.2.1 Conceptual support

Support for defining the term competence should be flexible, in that users are encouraged to define competence in a manner that suits their specific situation (Stoof, Martens, & van Merriënboer, 2004a). Thus, conceptual support needs to be useful for defining competence in many ways. At the same time, users need to have *some* clues in the definition procedure. One type of support that meets both requirements is the use of *dimensions* of competence. Hence, the issue is which dimensions of competence can be distinguished. Stoof, Martens, van Merriënboer, and Bastiaens (2002) proposed the following dimensions of competence: personal versus task characteristics; individual versus distributed competence; specific versus general competence; levels of competence versus competence as a level, and teachable versus non-teachable competence. Van Merriënboer, van der Klink, and Hendriks (2002) distinguished as dimensions of competence: specifity; integrativity; durability; focus on action; learnability, and interdependence. However, both series of dimensions are based on theoretical notions of the term competence without any direct practical considerations. Within the context of the intended tool, a competence definition should not only be theoretical but primarily be practical for the task of making a competence map.

An analysis of 16 already existing competence maps in a wide range of domains showed that competence maps typically incorporate a limited amount of information. Besides competencies, competence maps mainly contain information about levels of competence, contexts in which competencies play a role, and elements that together constitute a competency. In addition, competencies are regularly grouped into larger competency *areas*. Based on the theoretical analysis as well as the analysis of existing competence maps, six dimensions were distinguished. The first dimension, *levels*, concerns the issue whether or not competencies can be subdivided in, for example, starting level, advanced level and experienced level. The second dimension, *context*, has to do with the question whether or not competencies are connected to, for instance, tasks, roles, functions and situations. The third dimension, *relationships*, is about the issue whether or not competencies are related to each other. In dimension four, *elements*, the issue is whether or not competencies are composed of several parts, such as knowledge, skills and attitudes. Dimension five, *output*, concerns the question whether or not competencies lead to specific outcomes, such as a product, service, or behavior in general. The sixth dimension, *kinds*, deals with the question whether or not there are other competencies than just professional competencies, such as learning competencies, career competencies and competencies that are general to all kinds of profession. On the one hand, this approach enables flexibility in choice and personalization of competence definitions. On the other hand, the six dimensions provide anchors and guidance to think about the term competence.

4.2.2 Procedural support

The consequence of flexibility in conceptual support is that procedural support should be flexible as well. That is, procedural support should be designed in such a way that all different kinds of competence definitions can be used for describing and ordering competencies in a clear framework. Although there are many procedures for competency analysis, none of them is free of assumptions about the meaning of competence. When they are used for giving procedural support, they thus need to be adjusted in such a way that they can be used with various competence definitions. Basically, it means that fixed competence definitions in existing procedures have to be replaced by the competence dimensions that were distinguished in the conceptual support.

Procedural support for *describing competencies* can follow a three-step approach: (1) development of a linguistic format, (2) structured data collection, and (3) structured data analysis. A *linguistic format* is a formal template containing several "fields", which is used to make competence descriptions. It helps the user to incorporate the required information in every competence description, and it ensures that each competence description contains the same amount and type of information. The contents of a linguistic format should be based on the user's competence definition. That is, if a competence definition states that competencies have levels, the linguistic format should contain a "levels-field" as well. In this way, every competence description will contain information about the levels that can be distinguished within each competency.

Along the same lines, *data collection* should be based on the linguistic format. That is, if a linguistic format contains a "levels-field", data collection should include the gathering of information about levels of competencies. In this way, data are gathered in a structured and consistent way. Existing techniques provide valuable information about data gathering. Some techniques provide matrices that can be used to collect and represent information about competencies (Boon & van der Klink, 2001; Fletcher, 1997). Other types of support are exemplary questions that can be used to interview practitioners or other field experts (Boon & van der Klink, 2001; Cluitmans, 2002), and suggestions for consulting other sources that may provide relevant information about competencies in a particular area, such as vacancy advertisements and job profiles generated by branch organisations (Cluitmans, 2002).

The third step in describing competencies, *data analysis*, concerns the analysis of large amounts of qualitative data, such as interview reports and document analysis reports. Data analysis should also be governed by the linguistic format. Additionally, techniques for qualitative data analysis (e.g., Miles & Huberman, 1984; Strauss & Corbin, 1990) and techniques for knowledge elicitation and representation (e.g., Shadbolt & Burton, 1995) may be useful. The data analysis finally results in the competence descriptions.

Once the competencies have been described, users need to *order the competencies* in a general framework. This framework does not contain all information that is included in the competence descriptions, but rather summarizes the most important features so that a quick overview of the competencies is obtained. Obviously, the *content* of a framework depends on the competence descriptions. Similarly, the *kind* of framework depends on the content. There are many kinds of frameworks, such as lists, matrices, circle diagrams, pie charts, hierarchical tree structures, and “flower” models. These frameworks differ on two aspects: capacity and complexity. *Capacity* refers to the amount of information that a framework can contain. *Complexity* is the extent to which a framework can represent different and complex kinds of information in a clear and structured way. Bearing these variables in mind, procedural support for ordering competencies should help users to choose a framework that best fits their competence definition, linguistic framework and competence descriptions - and it should help them to “fill” the chosen framework with information.

Summarizing, conceptual and procedural support consist of the following five steps: (1) generate a competence definition by using dimensions of competence, (2) develop a linguistic format that is based on the competence definition, (3) collect data by means of the linguistic format, (4) analyse data by means of the linguistic format and make the competence descriptions, and (5) order the competencies into a general framework.

4.3 Supportive aids

The previous section defined the functionality of conceptual and procedural support. This section will describe the way in which such support can be designed. There are many different kinds of aids that may support designers who make competence maps. Four aids seem to be particularly useful for the intended tool: task managers, information banks, construction kits, and phenomenaria (Perkins, 1992). *Task managers* focus on the procedure that has to be followed while performing particular tasks. They provide descriptions of methods, rules, regulations, and directions for doing the task and should be designed in such a way that the user knows what to do at any time. The user should be guided in executing (sub)tasks, receive feedback, and be able to check whether a step has been succesfully completed. Task managers are also designated as "standardization support" (van Merriënboer & Martens, 2002). *Information banks* contain textual information about the task at hand. They may include databases, resources, references, and help-functions that give procedural and conceptual answers to specific user questions. Information banks should minimally contain a proper goal description (Anderson, 1985) and the amount of available information should be as minimal as possible. Research has shown that short texts are typically more effective than extensive ones (e.g., Carroll, 1998; van der Meij, 2003; van der Meij & Carroll, 1998). Information banks are also known as "library and information support systems" (van Merriënboer & Martens, 2002). *Construction kits* consist of prefabricated parts and processes that may support decision making, provide warnings for the consequences of particular choices, or generate--parts of--products. Examples of constructions kits are the "wizards" included in many Microsoft™ applications and templates for documents, spreadsheets and presentations. A well-designed construction kit takes over routine aspects of the task of making a competence map, so that cognitive processing resources are released that can subsequently be used for the problem-solving aspects of the task (Norman, 1993). Construction kits are also called "job aids" (McKenney, Nieveen, & van den Akker, 2002) or "task automation support" (van Merriënboer & Martens, 2002). Finally, *phenomenaria* are (case) examples that illustrate particular concepts and procedures. They should be based on real-life projects in which competence maps are developed. Guidelines for designing phenomenaria are provided in the literature on worked examples and case studies (e.g., Paas & van Merriënboer, 1994; Sweller, van Merriënboer, & Paas, 1990; Ward & Sweller, 1990).

The four types of aids are useful for the design of conceptual and procedural support in different ways. For *conceptual support*, an information bank, a construction kit and a phenomenarium can be used. An information bank provides general information about the possible dimensions of competence. A construction kit helps users to generate a definition by means of the dimensions. Finally, a phenomenarium provides concrete examples of both the use of dimensions for defining competence and the resulting competence definition. For *procedural support*, all four types of aids are useful. A task manager guides the user through the steps by which competencies are described and ordered. An information bank generally describes how to generate a linguistic format, how to collect data, how to analyze data, and how to choose a useful framework for organizing the competencies. A construction kit helps users to generate a linguistic format, provides templates for data collection and analysis, and helps users to choose a useful framework. Finally, a phenomenarium provides examples of processes and products with respect to a linguistic format, data collection, data analysis, competence descriptions and a framework.

To conclude, the analyses of the conceptual and procedural support and the supportive aids constitute the theoretical framework for the development of the tool. Its validity is grounded in this framework. The second requirement is that the tool must be practical, which is the main issue discussed in the next sections.

4.4 Design approach

In order to design a practical tool, a development strategy called *evolutionary prototyping* will be adopted. Parts or preliminary versions of the tool are repeatedly tested and improved until a final delivery has been attained (Nieveen, 1999). Evolutionary prototyping is an effective method because it involves intended users, domain experts and other stakeholders from the very beginning. Problems can be recognized in an early stage and revisions can be made until everyone is satisfied. Because of these benefits, the prototyping approach is used by many tool developers (see for an overview, Nieveen & Gustafson, 1999).

An evolutionary prototyping approach must be based on a thorough analysis of the target group members and their contexts and needs, as well as the task they must perform. The target group consists of all kinds of people who may be involved in the construction of a competence map, such as curriculum designers, teachers, educational managers, practitioners, field experts and branch representatives. Together they form a heterogeneous project team that is responsible for the construction process. Typically, they will meet several times "face-to-face". E-mail and telephone are used for additional communication, since team members are often located at different work places. The target group has a need for supportive tools or guidelines that help them to overcome the conceptual and procedural problems they encounter in the construction process, as analyzed and described by Stoof, Martens and van Merriënboer (2004a).

A second prerequisite for a successful design approach is an analysis of the task and the desired output. The task has been extensively discussed in the conceptual and procedural support section. The final output, a competence map, consists of three parts. The first part contains *competence descriptions*, which provide detailed information about each competency that is important for a certain job or professional domain. For example, one competence description may contain information about its output, its relationships with other competencies, the elements which the competency consists of, and an example of the competency as applied in practice. Competence descriptions constitute the core of a competence map and are used for developing a competence-based curriculum. The second part consists of a *competence figure*, which is a visual summary of the competence descriptions. Often, a competence figure is used as an aid to quickly communicate what a competence map is about. The third part contains *general information*, for example about the domain of the competence map, the goal, and the definitions used. This information is necessary to distinguish one competence map from another, since they may differ from each other on several aspects. As an example, a competence map that is developed for the area of Engineering contains descriptions of all Engineering competencies; a visual summary of Engineering competencies; and information about the goal of the competence map, the Engineering-domain, and definitions that were used for defining the Engineering competencies.

Finally, design choices in the evolutionary prototyping cycle can be based on the wide range of experiences with tool development for educational purposes. First, a tool should be adaptive and flexible, so that it meets the users' needs and wishes (Gustafson, 2002; van den Akker, 2003; van Merriënboer & Martens, 2002). Second, it is generally advised to work with a project team and project plans (de Bie, 2003). It is further recommended to incorporate representatives of all relevant stakeholders in the project team (de Bie, 2003; Kessels, 1999; van den Akker, 2003). In the context of constructing competence maps, stakeholders are for example teachers, curriculum designers, educational managers, governmental bodies and branch organizations. Third, the tool should be useful for both novices and experts (Gustafson, 2002). In addition, the area of ergonomics, interface design and web design pays great attention to the usability of tools. For example, there is a vast amount of guidelines about color use, navigation, typeface, page width, and use of "appetizers" such as dynamic effects and illustrations. Guidelines and heuristics for the proper application and use of these elements can be found in Brinck, Gergle, and Wood (2002), Nielsen (2003b), Schneiderman (1998), and Smith (2001). The next section describes the development and formative evaluation of the tool.

4.5 Method

Table 4.1 gives an overview of prototypes, participants, variables and methods used in the design and the formative evaluation of the tool. From here on, the tool is referred to as *COMET*, which is a loose acronym for Competency Modeling Toolkit.

Table 4.1: Design and formative evaluation of COMET.

Prototypes	Participants	Variables and methods					
		Design	Appeal	Goal	Content	Confidence	Relevance
COMET/1	Internet users (*n* = 5)	HE QU	HE QU	HE QU	QU	QU	QU
	Experienced users (*n* = 1)	QU IN	QU IN	QU IN	QU IN	QU IN	QU IN
COMET/2	Web designers (*n* = 1)	WA					
	Internet users (*n* = 2)	HE QU	HE QU	HE QU	QU	QU	QU
	Experienced users (*n* = 1)	QU IN	QU IN	QU IN	QU IN	QU IN	QU IN
	Domain experts (*n* = 19)				FG	FG	FG
COMET/3	Experienced users (*n* = 2)	QU IN	QU IN	QU IN	QU IN	QU IN	QU IN
	Novice users (*n* = 2)	QU IN	QU IN	QU IN	QU IN	QU IN	QU IN
	Experienced users (*n* = 2)	QU	QU	QU	HE QU	HE QU	HE QU
	Novice users (*n* = 2)	QU	QU	QU	HE QU	HE QU	HE QU
COMET/4	Experienced users (*n* = 1)	WA QU IN	WA QU IN	WA QU IN	WA QU IN	WA QU IN	WA QU IN
	Experienced users (*n* = 1)	WA IN	WA IN	WA IN	WA IN	WA IN	WA IN
	Novice users (*n* = 2)	WA QU IN	WA QU IN	WA QU IN	WA QU IN	WA QU IN	WA QU IN

Note. HE = Heuristic Evaluation; QU = Questionnaire; IN = Interview; WA = Walkthrough; FG = Focus Group.

4.5.1 Participants

Participants were obtained from five different groups: internet users, web designers, domain experts, experienced users, and novice users. Internet users are people who are regularly using the internet. Web designers build professional websites. Domain experts are knowledgeable about competence-based education and its development. Experienced and novice users are people from the target group. Novice users have never constructed a competence map and experienced users have constructed a map at least once.

Participants in the formative evaluation of the first prototype, COMET/1, were five internet users (1 male, 4 female) and one experienced user (male). In evaluating the second prototype, COMET/2, participants were one web designer (female), two internet users (1 male, 1 female), one experienced user (male), and 19 domain experts (12 male, 7 female). With the third prototype, COMET/3, four experienced users were involved (2 male, 2 female) and four novice users (4 females). Participants in evaluating the fourth prototype, COMET/4, were two expert users (1 male, 1 female) and two novice users (1 male, 1 female). One experienced user participated in the evaluation of each of the four prototypes; all other users participated only once.

4.5.2 Materials

Table 4.2 provides an overview of the content and supportive aids of the four prototypes. The content consists of a general interface; an introduction to COMET and the task at hand; the phases in which a competence map is constructed (i.e., initiation, construction, validation, and acknowledgement) and, finally, a part on the implementation of a competence map. The construction phase is the most extensive part of the website, comprising roughly 35%. The general interface contains a task manager as a supportive aid. The four phases are supported with an information bank, construction kit and phenomenarium. The implementation part contains an information bank only. Four successive prototypes were developed, with an increasing coverage and elaboration of content and aids. Note that the language used in COMET is Dutch, since it was initially developed for users in the Netherlands.

COMET/1

The first prototype, COMET/1, was implemented as a website. It consisted of a general interface, an introduction, and part of the first phase for constructing competence maps: initiation. The general interface included the task manager, providing navigational facilities to switch between web pages in general and more specifically to guide users in following the phases and steps in the right order. The introduction contained information about the use and purpose of the website, the target group, and some background information

Table 4.2: Content of prototypes.

Content	Type of Support	COMET/1	COMET/2	COMET/3	COMET/4
General interface	Task manager	x	x	x	x
Introduction		x	x	x	x
Phase 1: Initiation	Information bank	x	x	x	x
	Construction kit	x	x	x	x
	Phenomenarium				x
Phase 2: Construction	Information bank		x	x	x
	Construction kit			x	x
	Phenomenarium				x
Phase 3: Validation	Information bank				x
	Construction kit				x
	Phenomenarium				x
Phase 4: Acknowledgement	Information bank				x
	Construction kit				x
	Phenomenarium				x
Follow up	Information bank				x

about competence maps. Phase 1 contained an information bank and a construction kit.

COMET/3

In the third prototype, the introduction was extended with information about competence in general, competence-based education, and time investment with respect to the construction of competence maps. Information banks for phase 1 and 2 were extended as well. Compared to the second prototype, the main difference was the inclusion of ten construction kit tools for phase 2. Seven of these tools were templates or procedures. The three remaining tools were paper-and-pencil versions of tools that would be transformed into "intelligent" tools in COMET/4. The paper-and-pencil tools concerned (1) the generation of a competence definition; (2) the generation of a linguistic format that is used as template to make competence descriptions, and (3) the generation of a competence figure.

COMET/4

The fourth prototype contained all phases and all steps, including an information bank, a construction kit, and a phenomenarium. The phenomenarium consisted of an example case in which an imagined project team constructed a competence map in the area of information sciences. Process descriptions as well as resulting products were provided. The example case was based on interviews with practitioners in the area of information science.

Questionnaire

The questionnaire was designed to evaluate the practicality of the prototypes. Six variables were measured: design, appeal, goal, content, confidence and relevance. Design concerns the extent to which "surface" elements of COMET, such as the user interface and the navigation, are pleasant and easy to use. Appeal is the extent to which users like COMET and are motivated to actually use it. Goal refers to the extent to which it is clear for what purpose COMET has been designed and who should use it. Content is the degree to which the method implemented in COMET is clear and leads to a reliable and valid competence map. Confidence refers to the amount of trust users have in COMET, and if they perceive it as well-thought and actually helping them to perform the difficult task of constructing a competence map. Finally, relevance is the extent to which COMET suits the task that users have to perform.

The variable *design* was subdivided in eight subscales: Navigation, interface, usability, correction and prevention of errors, locus of control, short-term memory, text, and media. Navigation has to do with the ease to go from one web page to another, and to find the information that is needed. Interface refers to the consistent and proper use of structure and color, thereby supporting the use of COMET. Usability is the extent to which COMET is easy to use, with respect to download time as well as number of steps needed to get somewhere. Correction and prevention of errors is about the way COMET prevents errors and provides information on how to correct errors. Locus of control means whether the user or the computer is perceived to be "in charge" when using the website. Short-term memory concerns the extent to which texts are straight-to-the-point and the amount of information users have to memorize before switching to another web page. Text refers to appropriate language use, a correct "tone", and a good lay-out in terms of structure, contrast, typeface, color, etcetera. Media has to do with the function and appropriateness of illustrations and clips.

Subscales of *appeal* were attractiveness and motivating aspects. Attractiveness is the extent to which users "like" COMET. Motivating aspects concern the extent to which COMET encourages the user to use it.

Goal included the subscales purpose and target group. Purpose refers to what COMET does. Target groups concerns COMET's intended users.

Content was subdivided in clarity of the method, usability of the method, reliability of the method, validity of the method, and experienced support from the example. Clarity of the method refers to what happens in general in the phases and steps, and what the tools of the construction kit do. Usability of the method is about what to do when: When to take which steps, when to use tools, and when to proceed to another step. Reliability of the method is the extent to which a competence map can be replicated across time by the same design team. Note that because COMET adapts to each situation, different design teams are likely to design different competence maps in different ways. Validity of the method is the extent to which a competence map reflects the competencies of practitioners in a certain professional domain. Experienced support from the example is about the extent to which the example clarifies how to use the method.

The dependent variables *confidence* and *relevance* had no subscales. The 73 items in the questionnaire are largely based on usability questions and heuristics of Brinck, Gergle, and Wood (2002), Nielsen (2003a), Schneiderman (1998), Smith (2001), and Stoyanov (2001). Each item had to be scored on a Likert scale, ranging from 1 ("totally disagree") to 5 ("totally agree"). Example of items are: "The website is easy to use" and "The text is long". In addition, four open questions were added to enable participants to comment on omissions and failures and to provide suggestions for improvement. Table 4.3 gives an overview of variables, sub scales, and number and reliability of items.

Table 4.3: Variables, sub scales, instruments and internal consistency.

Variables	Sub scales	Questionnaire		Heuristic evaluation I	Heuristic evaluation II
		# items	Cronbach's α	# items	# items
Design	Navigation	4	.62	1	
	Interface	7	.70	1	
	Usability	5	.73	1	
	Correction and prevention of errors[a]	2	.62	1	
	Locus of control[b]	2	.83	1	
	Short-term memory	3	.64	1	
	Text	9	.76	1	
	Media	2	.52	1	
Appeal	Attractiveness	1	-	1	
	Motivating aspects[c]	3	.68	1	
Goal	Purpose	1	-	1	
	Target group	1	-	1	
Content	Clarity method	4	.67		1
	Usability method	4	.93		1
	Reliability method	1	-		1
	Validity method	2	.68		1
	Support example	5	.73		1
Confidence	-	6	.75		1
Relevance	-	4	.84		1
		Σ 73		*Σ 12*	*Σ 7*

[a] Two items were excluded in order to enhance the scale's internal consistency.
[b] Two items were excluded.
[c] One item was excluded.

Heuristic evaluation form I

Heuristics are usability principles or guidelines for interface design. Form I consisted of 12 heuristics for each of the sub scales of the dependent variables design, appeal and goal. The heuristics were adopted from Brinck, Gergle, and Wood (2002), Nielsen (2003a), Schneiderman (1998), and Smith (2001). The form consisted of three columns: one column naming each of the heuristics; one column for noting down comments on the heuristics, and one column for giving a grade between 1 ("total failure") to 10 ("outstanding"), which is the normal grading scale in Dutch schools.

Heuristic evaluation form II

Form II was designed in a way similar to form I, except that the heuristics covered the sub scales of the dependent variables confidence, content and relevance. The seven heuristics were based on the definitions of the subscales. Table 4.4 provides a description of the heuristics of both form I and II.

Interview format

The semi-structured interview consisted of questions that were based on negative answers on the questionnaire. That is, participants who gave either a "1" on positively formulated statements or a "5" on negative statements were asked to elaborate on these scores.

Walkthrough instructions

Instructions for the walkthrough were: "Go through all pages of the website in your own pace and manner." With COMET/2, the participant was additionally asked to specifically pay attention to the design aspects of the website. With COMET/4, participants were asked to pay attention to design, appeal, goal, confidence, content and relevance.

Focus group instructions

Instructions for the 19 domain experts in the focus groups with COMET/2 (see Table 4.1) were: "Please comment on COMET, in particular on the confidence COMET raises with its users; the content of the website, and the relevance of the website for the task of making competence maps."

4.5.3 Procedure

Evaluation of COMET/1

Internet users evaluated the website through a procedure known as *heuristic evaluation* (Nielsen, 1994, 2003a, 2003b). This method is often used in iterative design processes to collect information about interface usability, by using several usability heuristics. After a short introduction to the website and the evaluation procedure, individual internet users were given ten minutes at maximum to become acquainted with the website in their own way. Hereafter they were provided with the heuristics of form I and asked to go through the website for a second time, evaluating the heuristics one by one. Their verbal comments were noted down by the observer, who regularly asked the participants to elaborate on their comments. In addition, the participants rated each heuristic on a scale from 1 ("total failure") to 10 ("outstanding"). Comments and ratings were noted down on form I. Finally, participants were asked to describe problems with the website that did not show up in the heuristics. The heuristic evaluation procedure took 30 minutes maximally. Hereafter, the participants filled out the questionnaire. The experienced user was asked to go through the website in his own way and to fill out the questionnaire. Subsequently, an interview was conducted by telephone.

Evaluation of COMET/2

The web designer evaluated the website by means of a *walkthrough*. There are many ways to perform a walkthrough (Smith, 2001). In the formative evaluation of COMET, a walkthrough means that participants inspect each page of the website and note down comments. With COMET/2, the focus was on the design aspects of the website. Evaluations of internet users and experienced users were collected in a procedure similar to the evaluation of COMET/1. Further, two groups of domain experts (7 and 12, respectively) inspected the website in a procedure known as a *focus group*. Here, the website was presented to the domain experts, who were subsequently asked to reflect on it and to discuss its weak and strong points, in particular with regard to the issues confidence, content and relevance. The experimenter took notes of the discussion.

Evaluation of COMET/3

Individual experienced users and novice users were asked to go through the website in their own pace (30 minutes maximally). Hereafter, they were asked to use the three paper-and-pencil tools of the construction kit. In using the tools, participants had to use a list of eight arbitrary competencies. Meanwhile, the experimenter observed and made notes of the manner of use, mistakes and faults, and of the improvements suggested by the participants. Subsequently, participants were subjected to either a combination of questionnaire and interview, in a way similar to the evaluation of COMET/1, or a combination of heuristic evaluation and questionnaire, in a way similar to the evaluation of COMET/1 and COMET/2, except that form II was used instead of form I. All participants were asked what they would like to see in an example case.

Table 4.4 : Heuristics.

Heuristic	Description
Heuristic evaluation form I	
1. Navigation	The structure of the website should be clear. Users have to know where they are and how to come somewhere else. Users have to be able to find the information they are looking for easily.
2. Interface	The interface should be simple and consistent. The structure of the interface and the color use should match with the content and "tone" of the website. The structure has to support the use of the website.
3. Usability	Users should quickly find out how to use the website. The website should be easy to use. Pages should download quickly. Users should not have to perform too many actions to reach intended information.
4. Correction and prevention of errors	Errors should be prevented. If a user makes a mistake he or she should receive feedback and be able to quickly undo the undesired effects of errors.
5. Locus of control	Users should have the feeling that they decide what is happening rather than the website.
6. Short term memory	Pages should not be too long or contain too much or redundant information. The website cannot request that the user remembers information when navigating to another page.
7. Text	The text should be pleasant to read with respect to paragraphs, use of white lines, color, contrast and typeface. The language should be in accordance with the user and it should be clear and direct. Texts should not be too long and should have a beginning, middle section and end.
8. Media	Media (illustrations, clips, etc.) should fit the content of the website and have a clear function.
9. Attractiveness	The website should look attractive.
10. Motivating aspects	The website should motivate users to use it.
11. Purpose	The purpose of the website should be clear.
12. Target group	It should be clear who are the intended users of the website.
Heuristic evaluation form II	
1. Clarity method	The method should be clear. The user should quickly know how to use the method. It should be clear what happens in each of the steps and phases. The tools of the construction kit should be clear.
2. Usability method	The method should be usable. The user should know exactly what to do every time. It should be clear when the user has to go to a next step or phase, and at what time tools should be used.
3. Reliability method	The method should lead to a reliable competence map. When a user makes a competence map, a second one constructed three months later should be similar.
4. Validity method	The method should lead to a valid competence map. The competence map should be a good reflection of the competencies practitioners need in a certain professional domain.
5. Support example	The example should make clear how to use the method. The example should be clear.
6. Confidence	The website should raise confidence with the user. The user should have the impression that the website is constructed carefully. The website should look professional.
7. Relevance	The method should be relevant. The method should fit to the task of constructing a competence map in practice. People who build a competence map should gain from the method.

Evaluation of COMET/4

With experienced users data were gathered by means of either a combination of a walkthrough, questionnaire and interview, or just a walkthrough and interview. The walkthrough covered all six variables. Novice users inspected the website by means of a walkthrough, questionnaire and interview.

4.5.4 Analysis

From the quantitative data of the questionnaire and the heuristic evaluation forms we calculated means, standard deviations, minimum scores and maximum scores. On the qualitative data as obtained by the questionnaire, heuristic evaluation forms, interview, and focus group, no further analyses were conducted. All comments were used to improve the prototypes and to produce a final, high-quality tool.

4.6 Results and discussion

4.6.1 Formative evaluation of COMET/1

Quantitative. Table 4.5 shows the results of the questionnaire and the heuristic evaluation of COMET/1. Generally, scores indicate that participants are rather satisfied. There are no extreme values on any of the subscales, either positive or negative.

Qualitative. Participants reported several problems and gave suggestions for improvement. Most comments concerned the design subscales, in particular navigation, interface, text and media. For example, some combinations of text color and background were considered sub optimal; the menu did not show in which part of the website the user was, and the figure showing the general methods was unclear. Other comments mainly concerned the content of COMET/1, such as a lack of checklists and a supportive coach, and a too heavy focus on reading text instead of activating users to do something.

The results of the evaluation of COMET/1 lead to several changes in the design of COMET/2. The general interface was considerably altered in terms of color, text and media use. The part of the task manager guiding the sequence of phases and steps was adjusted, along with some changes in the general web structure. Finally, a checklist was added to phase 1.

4.6.2 Formative evaluation of COMET/2

Quantitative. Table 4.6 shows the results of the questionnaire and the heuristic evaluation of COMET/2. Again, participants seem to be rather content

Table 4.5: Formative evaluation of COMET/1.

	Subscale	*n*	*M*	*SD*	Min.	Max.
				Questionnaire		
Design	Navigation	6	3.63	0.26	3.25	4.00
	Interface	6	3.76	0.67	2.57	4.43
	Usability	6	4.13	0.52	3.40	4.80
	Correction and prevention of errors	6	3.25	0.69	2.00	4.00
	Locus of control	6	4.08	0.49	3.50	5.00
	Short term memory	6	3.72	0.44	3.00	4.00
	Text	6	3.65	0.50	2.89	4.33
	Media	6	3.92	0.59	3.00	4.50
Appeal	Attractiveness	6	3.67	1.03	2.00	5.00
	Motivating aspects	6	3.67	0.63	3.00	4.33
Goal	Purpose	6	3.83	0.98	2.00	5.00
	Target group	6	4.17	0.41	4.00	5.00
Content	Clarity method	6	3.00	0.47	2.25	3.50
	Usability method	6	3.29	0.86	1.75	4.00
	Reliability method	6	3.33	0.52	3.00	4.00
	Validity method	6	3.58	0.67	2.50	4.00
	Example	6	3.20	0.44	2.60	3.80
Confidence	Confidence	6	3.70	0.70	2.33	4.33
Relevance	Relevance	6	3.33	0.58	3.00	4.00
				Heuristic evaluation		
Design	Navigation	5	7.20	0.45	7.00	8.00
	Interface	5	7.60	0.55	7.00	8.00
	Usability	5	8.00	0.00	8.00	8.00
	Correction and prevention of errors	5	8.60	2.07	5.00	10.00
	Locus of control	5	8.20	1.10	7.00	10.00
	Short term memory	5	7.60	0.55	7.00	8.00
	Text	5	7.90	0.89	6.50	9.00
	Media	5	7.20	1.64	5.00	9.00
Appeal	Attractiveness	5	7.80	0.84	7.00	9.00
	Motivating aspects	5	7.50	0.50	7.00	8.00
Goal	Purpose	5	8.00	0.71	7.00	9.00
	Target group	5	7.80	0.45	7.00	8.00

Note. For the questionnaire, the scale ranges from 1 to 5 (“totally disagree” to “totally agree”). For the heuristic evaluation, the scale ranges from 1 to 10 (1 = “total failure”; 6 = “sufficient”; 10 = “outstanding”). High scores indicate high satisfaction with subscales.

with the website. Compared to COMET/1, participants tend to be slightly more positive.

Qualitative. Comments and suggestions for improvement were made with respect to the navigation subscale. Some other comments were that the website was not very attractive, that the intended target group was not clear, and that it was not clear when a user should proceed to a next step of the method or to go back to a previous one. Also, a general overview of steps and tools was requested.

Table 4.6: Formative evaluation of COMET/2.

	Subscale	*n*	*M*	*SD*	Min.	Max.
				Questionnaire		
Design	Navigation	3	3.67	0.38	3.25	4.00
	Interface	3	4.05	0.58	3.71	4.71
	Usability	3	4.00	0.20	4.20	4.60
	Correction and prevention of errors	3	3.33	0.29	3.00	3.50
	Locus of control	3	4.67	0.76	4.00	5.50
	Short term memory	3	3.78	0.39	3.33	4.00
	Text	3	3.89	0.51	3.44	4.44
	Media	3	3.50	0.50	3.00	4.00
Appeal	Attractiveness	3	3.67	1.53	2.00	5.00
	Motivating aspects	3	3.67	0.88	2.67	4.33
Goal	Purpose	3	5.00	0.00	5.00	5.00
	Target group	3	4.00	0.00	4.00	4.00
Content	Clarity method	3	3.67	0.88	2.75	4.50
	Usability method	3	4.17	0.29	4.00	4.50
	Reliability method	3	3.67	1.16	3.00	5.00
	Validity method	3	3.83	0.76	3.00	4.50
	Example	3	3.33	0.58	3.00	4.00
Confidence	Confidence	3	4.00	0.73	3.17	4.50
Relevance	Relevance	3	4.17	0.52	3.75	4.75
				Heuristic evaluation		
Design	Navigation	2	7.50	0.71	7.00	8.00
	Interface	2	8.00	1.41	7.00	9.00
	Usability	2	8.50	0.71	8.00	9.00
	Correction and prevention of errors	2	8.50	2.12	7.00	10.00
	Locus of control	2	8.00	0.00	8.00	8.00
	Short term memory	2	8.00	0.00	8.00	8.00
	Text	2	8.00	0.00	8.00	8.00
	Media	2	6.50	0.71	6.00	7.00
Appeal	Attractiveness	2	7.00	2.83	5.00	9.00
	Motivating aspects	2	7.50	0.71	7.00	8.00
Goal	Purpose	2	8.50	0.71	8.00	9.00
	Target group	2	8.00	1.41	7.00	9.00

Note. For the questionnaire, the scale ranges from 1 to 5 (“totally disagree” to “totally agree”). For the heuristic evaluation, the scale ranges from 1 to 10 (1 = “total failure”; 6 = “sufficient”; 10 = “outstanding”). High scores indicate high satisfaction with subscales.

Based on the results, several changes were incorporated in COMET/3, in particular with respect to the structure and content of some of the steps in phase 2. In addition, for more advanced users a web page was added providing a quick overview of phases, steps and connected tools.

Table 4.7: Formative evaluation of COMET/3.

	Subscale	*n*	*M*	*SD*	Min.	Max.
				Questionnaire		
Design	Navigation	8	3.25	0.68	2.50	4.25
	Interface	8	3.76	0.48	3.00	4.57
	Usability	8	3.89	0.52	2.80	4.40
	Correction and prevention of errors	8	2.79	1.19	1.50	5.00
	Locus of control	8	4.00	0.29	3.50	4.50
	Short term memory	8	3.48	0.72	2.00	4.00
	Text	8	3.67	0.79	2.00	4.33
	Media	8	3.64	0.56	3.00	4.50
Appeal	Attractiveness	8	3.43	0.98	2.00	5.00
	Motivating aspects	8	3.71	0.65	3.00	4.67
Goal	Purpose	8	4.43	0.54	4.00	5.00
	Target group	8	3.71	0.95	2.00	5.00
Content	Clarity method	8	3.82	0.35	3.25	4.25
	Usability method	8	3.71	0.55	2.50	4.00
	Reliability method	8	3.50	0.93	2.00	5.00
	Validity method	8	4.00	0.58	3.50	5.00
	Example	8	3.04	1.02	2.00	4.50
Confidence	Confidence	8	3.93	0.21	3.67	4.33
Relevance	Relevance	8	3.79	0.30	3.25	4.00
				Heuristic evaluation		
Content	Clarity method	4	7.25	0.50	7.00	8.00
	Usability method	4	7.25	0.96	6.00	8.00
	Reliability method	4	6.00	1.41	4.00	7.00
	Validity method	4	6.00	1.16	5.00	7.00
	Example	4	8.00	1.41	7.00	9.00
Confidence	Confidence	4	7.75	0.50	7.00	8.00
Relevance	Relevance	2	7.75	0.50	7.00	8.00

Note. For the questionnaire, the scale ranges from 1 to 5 ("totally disagree" to "totally agree"). For the heuristic evaluation, the scale ranges from 1 to 10 (1 = "total failure"; 6 = "sufficient"; 10 = "outstanding"). High scores indicate high satisfaction with subscales.

4.6.3 Formative evaluation of COMET/3

Quantitative. Table 4.7 shows the results of the questionnaire and the heuristic evaluation of COMET/3. Compared to COMET/2 there tends to be a small decrease of ratings, especially on the design and goal subscales. In particular the subscale correction and prevention of errors indicates a low mean, but the standard deviation, minimum and maximum score indicate that participants have very different opinions.

Qualitative. No comments were made about error correction and prevention. As in the evaluations of COMET/1 and COMET/2, comments mostly concerned design aspects such as color use, typeface and navigation. With respect to the paper-and-pencil tools, participants reported that some words or phrases were ambiguous or unclear. In addition, they asked for procedures or guidelines that would help them to incorporate information about competencies in a competence figure. Finally, recommendations were given for the design of an example case.

In the design of COMET/4, the results of the evaluation of COMET/3 lead to some minor changes in the information bank and construction kit of the introduction, phase 1, and phase 2. The recommendations for the paper-and-pencil tools were used for substantial improvements of the tools and for designing more “intelligent” versions of them. The recommendations for the example case were used to develop the phenomenarium.

4.6.4 Formative evaluation of COMET/4

Quantitative. Table 4.8 shows the results of the questionnaire that was filled out for COMET/4. The ratings on the subscales of the dependent variables goal, confidence and relevance tend to be higher than in the evaluations of COMET/1, 2 and 3. Ratings on the content subscales tend to be higher as well, with the exception of the reliability subscale. According to the mean, participants do not believe that a competence map made with the help of COMET will be identical to a second competence map that is constructed three months later by the same design team, again with the help of COMET. Because reliability measures on former prototypes were acceptable, the low mean may be attributed to the differences between COMET/4 and the other prototypes. Hence, the intelligent tools of the construction kit or the phenomenarium may have caused lower reliability ratings. However, the standard deviation, minimum score and maximum score show that participants differ greatly in their views of COMET’s reliability. This indicates that conclusions should be drawn with caution.

The ratings on the design subscales are roughly comparable to the ratings of the previous COMET versions. The appeal subscales, however, tend to show decreased ratings. In particular, COMET is considered to be not very attractive. This was mentioned in the qualitative evaluation of COMET/2 as well. It may therefore be concluded that the attractiveness of COMET should be increased.

Qualitative. Comments mainly concerned design aspects such as refusing hyperlinks and spelling errors. There were no comments about reliability and attractiveness.

The results of the evaluation of the fourth prototype were used to develop a final version of COMET. In this final version, only the spelling errors and refusing hyperlinks in COMET/4 were corrected.

Table 4.8: Formative evaluation of COMET/4.

	Subscale	*n*	*M*	*SD*	Min.	Max.
				Questionnaire		
Design	Navigation	3	4.17	1.01	3.00	4.75
	Interface	3	3.71	0.14	3.57	3.86
	Usability	3	4.07	0.61	3.40	4.60
	Correction and prevention of errors	3	3.00	1.00	2.00	4.00
	Locus of control	3	4.00	1.00	3.00	5.00
	Short term memory	3	3.22	0.77	2.33	3.67
	Text	3	3.41	0.45	2.89	3.67
	Media	3	3.33	1.26	2.00	4.50
Appeal	Attractiveness	3	2.33	1.16	1.00	3.00
	Motivating aspects	3	3.56	0.39	3.33	4.00
Goal	Purpose	3	5.00	0.00	5.00	5.00
	Target group	3	5.00	0.00	4.17	5.00
Content	Clarity method	3	3.83	0.58	3.75	4.50
	Usability method	3	4.50	0.66	2.00	5.00
	Reliability method	3	2.67	1.53	1.00	4.00
	Validity method	3	4.00	0.50	3.50	4.50
	Example	3	3.53	0.23	3.40	3.80
Confidence	Confidence	3	4.50	0.29	3.50	4.67
Relevance	Relevance	3	4.83	0.14	4.75	5.00

Note. The scale ranges from 1 to 5 ("totally disagree" to "totally agree"). High scores indicate high satisfaction with subscales.

4.7 General discussion

The central research question as posed in the Introduction was: What are the characteristics of a valid and practical tool that supports designers conceptually as well as procedurally in constructing a competence map? First, we started with a description of the functionality of conceptual and procedural support and the supportive aids that can be used for designing such support. These analyses guided the design choices in order to obtain a valid tool. Second, the practicality of the tool was studied. The design approach was discussed and an extensive description of the development and formative evaluation of the tool was presented. Four prototypes were developed and evaluated with intended users (both novices and experts), domain experts, internet users, and web designers.

The results of the formative evaluations show that each of the prototypes is acceptably practical with a small increase from COMET/1 to COMET/2, and, especially, from COMET/3 to COMET/4. Of all prototypes, COMET/4 appears to be the most practical one, with three exceptions. First, ratings on design were comparable to former prototypes. Although no improvements of the design of the website were realized, results show that participants are reasonably satisfied. Second, the attractiveness of the website is considered to be low. Because this was mentioned in the evaluations of former prototypes as well, attractiveness is one of the aspects of COMET that should be improved. Third, reliability measures are low as well. However, because of the large standard deviations improvements should be made with caution. In general, the practicality of the tool is acceptable except for the subscales attractiveness and reliability. The results of the evaluation of COMET/4 have lead to the development of a final version of COMET.

Notwithstanding the positive results of the formative evaluations, four remarks should be made. The first one concerns differences in the *depth of exploration*. Much time is required to examine the prototypes, especially COMET/3 and COMET/4. For example, COMET/4 has 88 pages, documents and tools, many of them of a considerable length. Therefore, the evaluations are based on a quick appraisal of many of the pages, documents and tools, of which only a few are explored in depth. Hence, ratings are not "definitive", since participants may have given other ratings when they would have explored other parts of the website. A second remark concerns the differences between *manners of exploration*. Participants differ in the way they explore the prototypes, which is a logical consequence of the instructions that were given to them. One participant may read a text on one page carefully, whereas another participant may totally ignore the same page. This makes it difficult to compare ratings. Large variations in minimum scores and maximum scores may therefore be a result of differences in exploration. Ideally, a formative evaluation should be designed in such a way that the depth and manner of explorations are fixed. Although this is not in line with the original heuristic evaluation procedure, it may be beneficial to adjust the instruction without large consequences for the quality of the heuristic evaluation. As a third remark, an *evaluation of COMET's final version* is still needed, so that definitive measures of its practicality are obtained. Ideally, this final evaluation is conducted with a larger number of participants than used in the present study, and the exploration depth and manner should be kept under control. The fourth remark concerns the *validity* of the tool. Although the theoretical framework as described in the Introduction is the basis for the tool's validity, it has not been evaluated with domain experts yet. In addition, one of the requirements of validity is that the components of the tool should be consistently linked to each other, which may very well be tested. Evaluations of validity may be incorporated in COMET's final evaluation.

The next sections describe the characteristics of the final version of COMET from three points of view: the perspective of the user, the perspective of the curriculum developer, and the perspective of the instructional designer.

4.7.1 Perspective 1: the user

The first perspective is that of the user. What does the user see and do when he or she uses COMET to construct a competence map? To the user, the most important characteristic of COMET is that it does not provide predetermined solutions. Instead, COMET provides means that help users to find their own solutions that are adaptive to the specific situation they are working in. Thus, different users will develop different products, for example with respect to the competence definition, the way in which competencies are described, and the design of the competence figure. A second characteristic of COMET is that the design process is set up as a project. One of the first steps that the user has to take is to compose a project team that will be responsible for the design of the competence map, and to make a project plan including a clear description of the targets, the deliverables, the time path, and the stakeholders. A third characteristic is the emphasis put on commitment. All members of the project team as well as the stakeholders must subscribe to the products that have been produced. A fourth characteristic is that COMET distinguishes three types of users: Novice users, experienced users and expert users, ranging from no experience with COMET to a lot of experience with COMET. All types of users are free to use COMET in their own preferred way, although COMET does provide some recommendations for each of the three user types. A final characteristic is that COMET can be used by individuals as well as groups, although collaborative group processes are not explicitly supported. COMET only concerns the task of making competence maps.

COMET consists of an introduction, a method, a case example and references. Through the *introduction* the user becomes acquainted with COMET's purpose and target group, and with the concept of competence, competence maps and competence-based education. The introduction prepares the user for the complex task of designing competence maps, in that the user learns what to expect and especially not to underestimate the difficulty of the task and the considerable time investment required. The *method* is at the heart of COMET and guides the user through four phases for developing a competence map: initiation, construction, validation and acknowledgement. In the initiation phase the user makes preparations for the construction phase. In the construction phase, the user develops the competence map. An important characteristic of this phase is that the competence definition that is constructed in the first step is the basis for all further steps. In the validation phase, the competence map is validated with subject matter experts, and in the fourth phase the competence map is formally acknowledged by all stakeholders. In addition, COMET provides some information about the subsequent trajectory: the follow up. Table 4.9 provides an overview of the four phases and the steps they consist of.

While taking the steps, the user is supported by a task manager that explains what to do when; an information bank that provides detailed written

Table 4.9: Phases and steps in COMET's method section.

Phase	Step	Description
Phase 1: Initiation	Define formal constraints	Mapping formal constraints as imposed by the government or national public bodies.
	Compose project team	Composing a project team that will develop the competence map.
	Make project plan	Formulating a project plan containing descriptions of the targets, planning, responsibilities and stakeholders.
Phase 2: Construction	Make competence definition	Constructing a competence definition that all team members understand and agree upon.
	Make linguistic format	Developing a linguistic format that will be used as a standardized format for describing competencies.
	Collect data	Collecting the data that will be used for identifying and formulating competencies, for example from practitioners.
	Make competence descriptions	Analyzing the data and describing competencies by using the linguistic format.
	Make competence figure	Summarizing the competence descriptions in a visual representation.
	Describe general information	Describing the goal and domain of the competence map, the definitions used, and other typical information.
Phase 3: Validation	Validate competence map	Validating the competence map with for example domain experts.
	Give feedback to competence map	Deciding if and how the competence map should be improved, based on the evaluation results.
Phase 4: Acknowledgement	Acknowledge competence map	Realizing a formal acknowledgement of the competence map with all stakeholders.
	Close project	Closing and eventually evaluating the project.

information about performing the task at hand; a construction kit, consisting of highly specific tools that simplify tasks; and a phenomenarium, which is a case example with both process and product descriptions. Figure 4.2 shows one of the pages of COMET including the different types of aids. Every phase is introduced with a summary of the steps, and is concluded with a checklist that can be used to make sure that all steps have been taken. Also, every page of the method contains a "help" function, which provides answers to Frequently Asked Questions (FAQ's), general guidelines for using COMET, and tips for applying the method. The phenomenarium is also included as a whole in the *case example*. There is a two-way relationship between the steps in the method and the corresponding steps in the case example, so that the user can navigate back and forth from method to example and vice versa. Finally, the *references* give an overview of relevant literature that designers can use to gather more background information on specific steps. These references can be accessed from each step of the method as well.

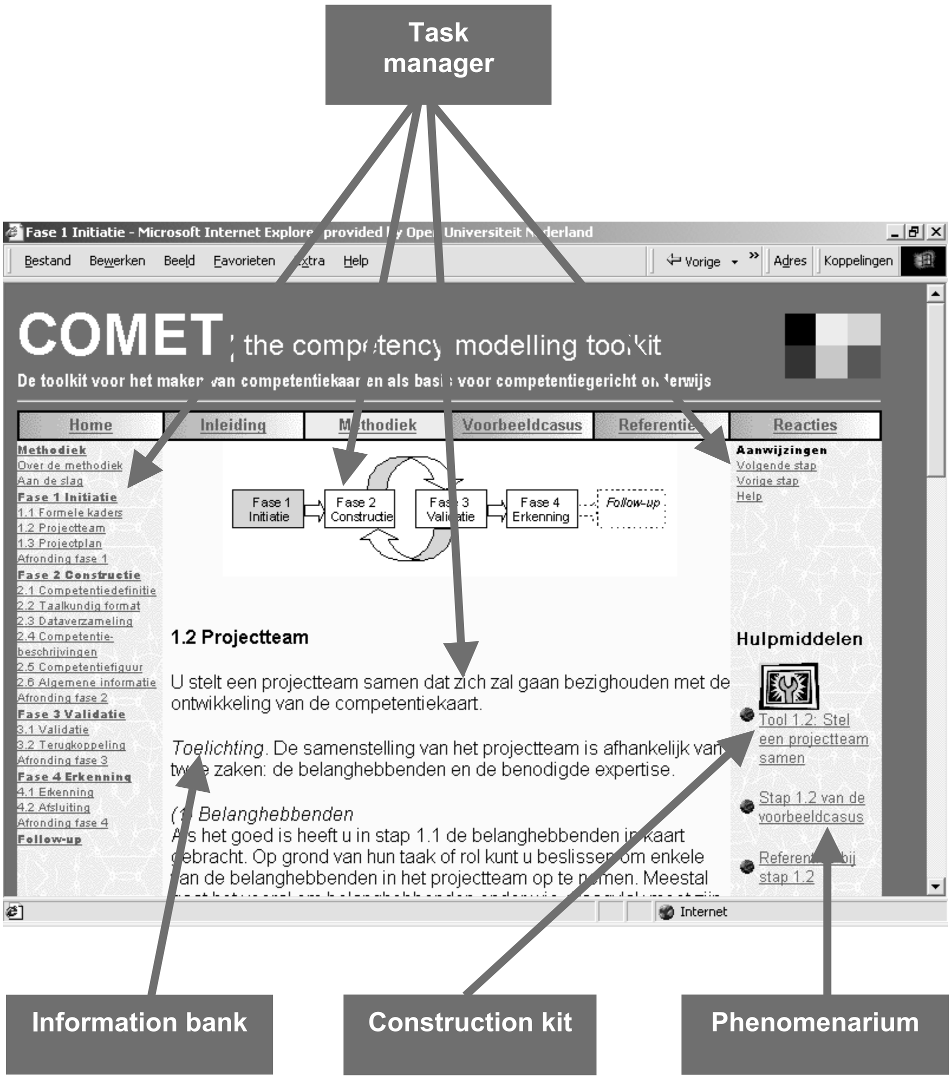

Figure 4.2: Supportive aids in COMET.

4.7.2 Perspective 2: the curriculum developer

The second perspective is that of the curriculum developer who actually designs curricula, course plans and lessons. Curriculum developers are confronted with a vast amount of computer-based tools that support them in their design activities. These tools differ in various respects, such as the task that is supported, the type of support, and the deliverables. Nieveen and Gustafson (1999) developed a framework to classify and describe instructional design tools, in order to help curriculum developers to choose between them. This framework is used to describe COMET from a curriculum developer's point of view. The main categories of the framework are: (1) type of output; (2) purpose and evidence of benefits; (3) type of development process supported and any underlying theory; (4) task support; and (5) intended users group.

Type of output

COMET's output, that is, a competence map, concerns the entire curriculum and not just a few lessons or a course. The competence map is not to be used by students but rather by curriculum developers and teachers to develop a competence-based curriculum. The extensiveness of the competence map varies. Competence maps can be developed either for site specific situations with a relatively small target group and small physical distances between all persons involved, or for generic situations with large and diverse target groups and large physical distances. Finally, the competence map consists of a competence figure, competence descriptions and general information (see "design approach"), which are all included in a text document.

Purpose and evidence of benefits

COMET's purpose is to improve the performance of design teams who are making competence maps and to improve the resulting products. As for the evidence, the issues of validity and practicality have been extensively discussed in this article. The collection of evidence for the *effect* of COMET on the construction of competence maps will be the subject of future research.

Type of development process supported and any underlying theory

The method used for developing COMET is evolutionary prototyping, which Nieveen and Gutafson designate as the "pragmatic paradigm". In the development process the five systematic design elements have been incorporated: analysis, design, development, implementation and evaluation (ADDIE). Because of the evolutionary prototyping approach, the development, implementation and evaluation steps were carried out simultaneously. Nieveen and Gustafson further distinguish three teaching or learning theories that may be used as a paradigm for tool development. These theories do not directly apply to our study since COMET does not deliver materials that are ready for use in teaching. However, our approach reflects a constructivist approach because users are expected to define their own problems and solutions and have to generate and specify their own products, for which COMET only provides the supportive aids.

Task support

COMET is designed as a website and provides support in the form of job aids: a task manager, a construction kit, a phenomenarium, and an information bank. Designers are free to determine which aids to use and when to use them, although COMET does provide a preferred route plan. Further, a large part of COMET is a so-called closed support system, in which users are not enabled to enrich the tool with their own experiences. A smaller part of COMET (especially the construction kit) adapts support from outside the tool, in that users can modify and edit text files.

Intended user group

The expertise of the users has a wide range because competence maps are typically developed by a heterogeneous team. People who are often involved are curriculum designers, educationalists, teachers, educational managers, subject matter experts and branch representatives. The scope of the intended user group is broad in that it is suitable for various organizations. Finally, users need to have some computer experience with the internet and text files in order to be able to use COMET.

4.7.3 Perspective 3: the instructional designer

The third perspective is that of the instructional designer involved in the development and evaluation of instructional design tools. His or her interest mainly concerns the design principles that result from developmental research. The design principles that result from our research with COMET can be based on the format proposed by van den Akker (1999, p. 7): "If you want to design intervention X [for the purpose/function Y in context Z], then you are best advised to give that intervention the characteristics A, B and C [substantive emphasis] and to do that via the procedures K, L and M [procedural emphasis], because of arguments P, Q and R.".

When this format is applied to the construction of competence maps, the design principles may be formulated as follows: If you want to design a tool that supports designers in constructing competence maps within the context of education, then you are advised to give the tool the following characteristics: (1) include a construction kit; (2) include a phenomenarium; (3) include a condensed information bank, and (4) include a task manager. The construction kit should be designed in such a way that it frees up cognitive processing resources that can then be used for the problem-solving aspects of the task (Norman, 1993). The phenomenarium should provide worked examples or case studies that can be used as analogies to perform the task (e.g., Gick & Holyoak, 1980; Sweller, van Merriënboer, & Paas, 2003). The information bank should contain limited (or summarized) information about the goals of the task and provide heuristics or rules-of-thumb for how to take the steps (Anderson, 1985). The task manager should guide users through the design process by showing the steps to be taken, by guiding them in executing those steps, and by providing feedback. In general, all aids should be characterized by flexibility, in that different views on the meaning of competence are allowed and that procedures for identifying and describing competencies are applicable to a wide range of competence definitions.

To conclude, the design choices that were based on the theoretical underpinnings as described in the introduction of this article, have lead to the development of a tool that has promising evaluative results. First, the formal evaluations of the tool's practicality showed acceptable results, although improvements of attractiveness and reliability are still desirable. Second, summative evaluations that have just been completed showed that particular components of the tool are effective as well (Stoof, Martens, & van Merriënboer, 2004b, 2004c). Given these promising results, COMET may be a strong aid for supporting design teams in performing the complex task of designing competence maps and so provide a good basis for the development of a competence-based curriculum.

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Part C: Experimental evaluation

Contents:

5

The perceived effects of web-based support for the construction of competence maps[5]

Abstract. Educationalists experience difficulties with the construction of competence maps that describe final attainment levels of educational programs. Web-based support was developed with three supportive aids: a construction kit, a phenomenarium, and an information bank. Each supportive aid was expected to improve perceived process and product quality as well as learning. In a factorial experiment, 266 educational science students constructed a competence map, whether or not supported by each of the three supportive aids. The availability of the construction kit and the phenomenarium had positive effects on perceived process quality and learning. Furthermore, if there was no phenomenarium with example materials, the absence of the construction kit greatly diminished experienced support (i.e., one aspect of process quality); if a phenomenarium was present, the availability of the construction kit had relatively little effect on perceived support. In general, this study indicates that well-designed web-based support helps to construct competence maps.

[5] This chapter is submitted as: Stoof, A., Martens, R. L., & Van Merriënboer, J. J. G. (2004). *The perceived effects of web-based support of the construction of competence maps*. Manuscript submitted for publication.

5.1 Introduction

The construction of a competence map, which describes the final attainment levels of an educational program in terms of—interrelated—competencies and sub competencies (Schlusmans, Slotman, Nagtegaal, & Kinkhorst, 1999), is a difficult design process. The goal of the present study is to test if a web-based support system may help designers to construct a competence map. In particular, the perceived effects of a construction kit, a phenomenarium, and an information bank on the quality of the construction process and the product of this process (i.e., the map) as well as on learning about the construction of competence maps were studied. In the web-based support system, the construction kit consists of pre-fabricated parts and processes; the phenomenarium provides useful examples, and the information bank presents explicit information and guidelines.

Earlier research has shown that the construction of a competence map is characterized by conceptual and procedural bottlenecks (Stoof, Martens, van Merriënboer, & Bastiaens, 2002; Stoof, Martens, & van Merriënboer, 2004a). Conceptual bottlenecks mainly pertain to difficulties designers experience with defining and demarcating the concept of competence and related terms such as knowledge, skills, expertise and ability. Procedural bottlenecks mainly pertain to difficulties with describing competencies and ordering them into a clear framework; unfortunately, there are yet no unequivocal procedures or supportive tools that help designers with determining and describing curriculum content in terms of competencies (van Merriënboer & Martens, 2002). This is a substantial problem, because a competence map is the main foundation for the development of a competence-based curriculum (de Bie, 2003). A possible solution is to provide teachers, educational managers and professionals who construct competence maps with a *task manager*, that is, an agent (software tool or teacher) showing which things to do when, by setting tasks to be undertaken, guiding users in executing those steps, and providing feedback on the quality of the process and the product.

A task manager can be combined with a construction kit, a phenomenarium and an information bank (typology after Perkins, 1992). A *construction kit* consists of prefabricated parts and processes that are specifically designed for executing a particular task. Essentially, a construction kit takes over some—routine—aspects of performing this task. The most important considerations and theoretical notions have been incorporated in the construction kit, so that users do not have do deal with these issues themselves. For example, a construction kit leads the user through a prefabricated decision process, resulting in a personal standpoint, a particular presentation format, or another kind of product. The "wizards" that are included in many Microsoft applications are examples of a construction kit. After asking a few questions, they generate a document or other type of file that is specifically adapted to the users' needs. A *phenomenarium* consists of extractions, simplifications, simulations or models of the real world. It provides analogies that can be used for problem solving and decision making in performing a task. In its simplest form, a phenomenarium provides plain examples such as video recordings of presentation skills. More sophisticated phenomenaria may be interactive environments that can be manipulated by the learners, such as computer-based training programs on air traffic control. Finally, an *information bank* provides explicit information about several topics. It explains phenomena, names causes, gives background information, provides guidelines for performing particular tasks, and so forth. Straightforward examples of information banks are dictionaries and encyclopaedias. Examples that are specifically related to task performance are checklists, job aids and on-line help systems in computer applications.

The central research questions of this article are: (1) Do a construction kit, phenomenarium, and information bank improve the process quality of making a competence map? (2) Do they improve the quality of the products that result from this process? (3) Do they have a positive effect on learning to construct competence maps? With respect to the first research question, it is expected that the availability of a construction kit improves the quality of the design process. More specifically, perceived satisfaction, efficiency, control, and support are expected to increase, whereas invested mental effort (i.e., cognitive load) and time for performing the task are expected to decrease if a construction kit is available. Because a construction kit offers tools that take over routine aspects of the design task, it frees up processing resources that task performers can then use to perform the problem-solving aspects of the task (Norman, 1993). Furthermore, a phenomenarium is expected to improve process quality because it provides worked examples that may be used as analogies to perform the task at hand. It has been well documented in the literature that analogies enhance reasoning and problem solving processes (e.g., Gick & Holyoak, 1980; Holyoak & Thagard, 1995), and that worked examples are extremely important to guide novices' design processes (e.g., Renkl & Atkinson, 2003; Sweller, van Merriënboer, & Paas, 1998). An information bank is also expected to improve the process quality because it provides clear descriptions of the goals that should be reached by the task performer, as well as guidelines and heuristics that may help to reach those goals (Anderson, 1985; Reitman, 1964). However, a condensed information bank is probably more effective than an information bank with comprehensive prescriptions and explanations. Work on "minimal manuals" in the field of Minimalism has consistently found that less information is typically more effective than more information (see Carroll, 1998; van der Meij, 2003; van der Meij & Carroll, 1998), and work in the field of multimedia has found that concise explanations, which leave out interesting but irrelevant materials (also called "seductive details"), are more effective than embellished explanations (e.g., Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2000).

With regard to the second research question, we expected an increase of perceived usability, clarity and trust when a construction kit, phenomenarium and information bank were available. If those supportive aids indeed improve process quality, it seems obvious that they enhance product quality as well. However, an important mediating factor between the process and the product quality pertains to the design characteristics of the supportive aids. For example, a construction kit incorporates some predetermined choices on the "ingredients" of the intended product. When these choices are sub optimal, the construction kit may be helpful for the user because it simplifies the process, but nevertheless yield a low product quality. This may be compared to the use of templates in a word processor; in general, such templates simplify the writing process but if they are badly designed they may nevertheless have a negative effect on the product. In order to prevent this discrepancy between process and product quality, the design characteristics of the supportive aids should be carefully assessed beforehand.

With regard to the third and last research question, we expected that supportive aids are helpful to perceived learning. The availability of a construction kit does not primarily support theoretical thinking or considerations at a meta-level, but clearly provokes learning-by-doing. It invites the user to actively work with predefined parts and processes, which facilitates inductive learning processes. Furthermore, a phenomenarium evokes analogical thinking: users learn in terms of stored solutions, adaptation to new problems and generalized schemas (Thagard, 1996). Similarly, research has shown that the study of worked examples, if properly designed, leads to better schema acquisition and transfer performance than solving the equivalent problems does (e.g., Paas, 1992; Paas & van Merriënboer, 1994). Finally, an information bank provides materials for the "early phase" of cognitive skill acquisition, that is, the acquisition of domain knowledge (van Lehn, 1996). It is expected that especially condensed information banks will improve learning, because novices learn more from a summary than from a full text (Reder & Anderson, 1980, 1982) and "a text that spells everything out and explains everything to the last detail does not leave enough room for constructive activities on the part of the learner" (Kintsch, 1994, p. 301).

We tested the effect of a construction kit, phenomenarium, and information bank on perceived process quality, product quality and learning in a factorial experiment. Eight conditions were designed, containing a task manager plus one of the eight possible combinations of construction kit (present or absent), phenomenarium (present or absent) and information bank (full or condensed). Participants had to construct several components of a competence map while working in one of the eight conditions. The effect of a construction kit was tested by comparing the group with a construction kit to the group without a construction kit. The effect of the phenomenarium was tested in a similar way. To test the effect of an information bank, we compared the group with a full information bank to the group with a condensed information bank.

5.2 Method

5.2.1 Participants

The participants were 266 first-year students from the Department of Education of the University of Gent in Belgium (239 females and 27 males; aged between 17 and 33 years, M = 18.54, SD = 1.51). The experiment was part of a regular, introductory course on educational design. All students were obliged to participate in the three-hours experiment. At the time of the experiment the students had not received any lessons on competence-based education, the construction of competence maps, or the significance of competencies for the field of education. In each session the participants were randomly assigned to one of the eight conditions. The size of the experimental groups is between 32 and 34 participants.

5.2.2 Materials

COMET

COMET (a loose acronym for Competence Modelling Toolkit) incorporates a task manager as well as a construction kit, phenomenarium and information bank. It is a web-based tool designed to support educational practitioners in constructing a competence map. COMET has been developed by means of evolutionary prototyping (e.g., Nieveen, 1999), focusing on its usability, quality of content and quality of supportive aids. People involved in the evaluation cycles were domain experts and intended users, both novices and experts in the field of competence-based education. Since COMET is developed for institutes of higher education in The Netherlands, all texts are written in Dutch. The theoretical background and the development process of COMET, including results of usability testing, are described in Stoof, Martens and van Merriënboer (2004b).

The main part of COMET involves the construction of a competence map. This construction process takes place in six steps. In the first step users make a *competence definition* that fits their own situation, needs and views on competence. The second step concerns the construction of a *linguistic format*, that is, a framework for describing competencies. It defines which elements should be incorporated in competence descriptions, for example the name of the competence, the relationships with other competencies, the levels that are distinguished within the competence, and so forth. In the third step *data* are gathered, for example from the relevant literature, field experts and practitioners. These data provide the material from which competencies are derived and described, which is done in step four. These detailed *competence descriptions* are the basis for developing a competence-based educational program or curriculum. In step five, the competence descriptions are put into a *competence figure*. This is essentially a visual summary of the competencies, for example a pie chart, matrix or hierarchical tree structure. The competence figure provides an overall impression and serves as the "signboard" of a competence map. In the sixth step, finally, *general information* about the competence map is added. It contains, for example, the goal and domain of the competence map, and the competence definition used. This is important information since competence maps tend to differ from each other on these aspects.

The *task manager* provides information about when to take which step. It mainly consists of navigation facilities plus a description of each step in one or two sentences. Additionally, different versions of COMET may or may not contain construction kits, phenomenaria and information banks, and combinations of these components. The *construction kit* contains small tools that support users in taking a certain step. For instance, one tool generates a partially filled out template for a competence definition, just by clicking on some statements. The *phenomenarium* provides examples that illustrate the application of one or more steps. In COMET, all examples are related to an invented case in which a design team in an institute for higher professional education constructs a competence map in a stepwise manner. It contains procedural information, intermediate products and final products. The *information bank* contains detailed descriptions of every step, with suggestions about how to take the step, warnings about pitfalls and tips how to avoid them, and information about things that should specifically be looked after.

For the purpose of the present study eight versions of COMET were developed: INFPHECON, INFCON, INFPHE, INF, PHECON, CON, PHE and TM-ONLY. Each version contains the task manager plus one of the eight possible combinations of construction kit, phenomenarium and information bank. The construction kit and phenomenarium are both either present or absent. The information bank can either be full, with detailed steps, suggestions and tips, or condensed, where the steps have been reduced from an extensive text to only three to five sentences by an independent person (see Table 5.1). For example, condition INFPHECON contains the task manager plus a full information bank, a phenomenarium and a construction kit. Figure 4.2 shows one of the pages of the INFPHECON-condition.

Table 5.1: Description of the eight different conditions.

		Information bank			
		full		condensed	
		Construction kit		Construction kit	
		present	absent	present	absent
Phenomenarium	present	INFPHECON	INFPHE	PHECON	PHE
	absent	INFCON	INF	CON	TM-ONLY

Manual

The manual contained information about the purpose and procedure of the experiment; some background-information about competencies, competence maps, competence-based education and COMET; and finally three tasks. Participants were asked to construct several parts of a competence map for the area of education: (1) a definition of competence, (2) a linguistic format, and (3) a competence figure. These tasks corresponded to the bottlenecks as described in the Introduction. For the other steps from the six-step model (i.e., data gathering, description of competencies, and specification of general information) no task was given. In advance to the experiment the manual had been tested to make sure that the participants were able to complete the tasks within the available time.

Cognitive load measures

Being one of the process variables, cognitive load refers to the mental effort participants put into completing the steps. In the manual, each of the four tasks was followed by a question on cognitive load (adopted from Paas, 1992 and Paas, van Merriënboer, & Adam, 1994), to be scored on a 9-point Likert-scale (1 = very, very low mental effort; 9 = very, very high mental effort). Cognitive load was treated as one aspect of process quality, that is, if performance of a task requires little effort this is seen as one indicator of high process quality.

Time investment

Participants were asked to note down the time as given by the computer clock directly after finishing the final task.

Questionnaire

The questionnaire consisted of 97 statements, to be scored on a 7-point Likert-scale (1 = absolutely not true; 7 = absolutely true). The questionnaire was developed in order to measure process quality, product quality, and learning effect. In addition to the cognitive load measures, *process quality* was measured in the questionnaire by four dependent variables: satisfaction, efficiency, control, and support. Satisfaction is defined as the amount in which users are content when working on the tasks and on the construction of a competence map in general. Statements on satisfaction were adopted from the questionnaires described by Deci, Eghrari, Patrik and Leone (1994), and Ryan, Connell and Plant (1990). Efficiency is the degree to which users have the feeling not to spend too much time on tasks. Control is the extent to which users know what to do and how to do it. Support is the amount of help users experience in using COMET. Every process variable contained statements concerning the three separate tasks in the manual, and the tasks in general. For example, satisfaction was measured with respect to the task of making a competence definition, the task of making a linguistic format, the task of making a competence figure, and the tasks in general. *The product quality* was made operational in three dependent variables: usability, clarity and trust. Usability is the extent to which users think that products can be used for the purpose they have been made for. Clarity is the extent to which users think that products do not contain ambiguous words or concepts. Trust, finally, is the measure in which users are pleased with their products and have confidence in them. Similar to the process variables, all product variables contained statements concerning both the three separate tasks and the tasks in general. Statements on *learning effect* only concerned the tasks in general.

In addition to the statements on process quality, product quality and learning effect the questionnaire contained three single statements on possible confounders: problems with using COMET, such as not being able to open certain pages; clarity of the tasks; and the amount of prior knowledge on competence maps, competence-based education and competencies in general. The statements on all dependent variables were reliable. The questionnaire has been screened on the correct use of the Dutch language as employed in the Flemish part of Belgium. Table 5.2 gives an overview of all dependent variables, the number of items, and reliability measures.

Table 5.2: An overview of the dependent measures and their internal consistencies.

		Number of items	Cronbach's α
Process quality	Satisfaction	12	.91
	Efficiency	12	.88
	Control	12	.88
	Support	12	.94
	Cognitive load	4	.68
	Time investment	1	-
Product quality	Usability	15	.85
	Clarity	12	.89
	Trust	12	.91
Learning effect		6	.89

5.2.3 Procedure

The experiment was conducted during seven sessions, spread over three days. Students were explicitly asked not to communicate with other students about the experiment afterwards. All participants were provided with a manual, scrap paper, a questionnaire, and a computer that could be used to consult one of the eight versions of COMET. After a short introduction to the experiment, participants individually worked on the three tasks described in the manual (135 minutes at most). When the participants started with reading the manual, the experimenter noted down the time as given by the computer clock. The tasks described in the manual were supported by COMET. At five predetermined moments, the session leader gave a notification to all participants in order to make sure that they would not run out of time. Participants were allowed to do something else after completing the tasks. The participants simultaneously filled out the questionnaire after a sign of the session leader (at most 25 minutes were available for this).

5.2.4 Analysis

We conducted a multivariate analysis of variance (MANOVA) for *process quality* with a construction kit (yes or no), a phenomenarium (yes or no), and an information bank (full or condensed) as between-subjects factors, and satisfaction, efficiency, control, support, cognitive load and time investment as dependent measures. This overall MANOVA included data from task 1 (definition of competence), task 2 (linguistic format) and task 3 (competence figure). In addition, we conducted three separate MANOVA's for the single tasks, taking into account data from either task 1, 2 or 3. We conducted an overall MANOVA for *product quality* with the same between-subjects factors and with usability, clarity and trust as dependent measures. Again, we conducted three separate MANOVA's on the data of either task 1, 2 or 3. Finally, we conducted an univariate analysis of variance (ANOVA) for *learning effect*, again with construction kit, phenomenarium and information bank as between-subjects factors. In all analyses, statistical assumptions were considered. Post-hoc analyses on the MANOVA's were conducted by means of univariate ANOVA's. For all statistical analyses, a significance level of .05 was applied.

5.3 Results

Table 5.3 shows the means and standard deviations of all dependent measures for the eight different conditions. Means on the three possible confounders: problems in using COMET, task clarity, and prior knowledge, were roughly equal for all conditions.

table53_page128.pdf

Process Quality

The overall MANOVA showed a main effect of the construction kit on process quality, Wilks' Lambda = .66, $F(6, 253) = 21.50$, $p < .001$. Univariate ANOVA's demonstrated that this effect was due to the dependent variables support, $F(1, 258) = 75.93$, $MSE = 99.46$, $p < .001$, $\eta^2 = .23$, control, $F(1, 258) = 18.62$, $MSE = 19.60$, p <.001, $\eta^2 = .07$, time investment, $F(1, 258) = 7.62$, $MSE = 4004.06$, p = < .01, $\eta^2 = .03$, and efficiency, $F(1, 258) = 7.04$, $MSE = 7.10$, $p < .01$, $\eta^2 = .03$. In the group with a construction kit, support and control are judged higher (in order $M = 5.05$, $SD = 1.21$ for support, and $M = 3.80$, $SD = 1.08$ for control) than in the group without a construction kit ($M = 3.83$, $SD = 1.25$ and $M = 3.25$, $SD = 1.02$, respectively). In contrast, time investment is higher in the group with a construction kit ($M = 120.77$, $SD = 25.42$) than in the group without a construction kit ($M = 113.00$, $SD = 22.08$). Finally, the group with the construction kit judges efficiency lower ($M = 4.63$, $SD = 1.06$) than the group with no construction kit ($M = 4.96$, $SD = 0.93$).

In addition, the overall MANOVA showed a main effect of the phenomenarium on process quality, Wilks' Lambda = .87, $F(6, 253) = 6.36$, $p < .001$. Univariate ANOVA's revealed that the effect was caused by the dependent variables support, $F(1, 258) = 31.01$, $MSE = 12.99$, $p < .001$, $\eta^2 = .11$, and control, $F(1, 258) = 12.33$, $MSE = 12.99$, $p < .01$, $\eta^2 = .05$. In the group with a phenomenarium, support and control are judged higher ($M = 4.83$, $SD = 1.29$ for support, and $M = 3.75$, $SD = 1.11$ for control) than in the group without a phenomenarium ($M = 4.04$, $SD = 1.35$ and $M = 3.30$, $SD = 1.01$, respectively).

Finally, the overall MANOVA showed an interaction effect of the phenomenarium and construction kit on process quality, Wilks' Lambda = .94, $F(6, 253) = 2.72$, $p < .05$. According to univariate ANOVA's this effect was caused by the dependent variable support, $F(1, 258) = 7.83$, $MSE = 10.26$, $p < .01$, $\eta^2 = .03$. Figure 5.1a shows the interaction effect on support. If there is no phenomenarium, the absence of the construction kit greatly decreases the experienced support; if there is a phenomenarium, the absence or presence of the construction kit has relatively little effect on perceived support. There were no other interactions and there was no main effect of the information bank.

The separate MANOVA taking into account only data related to the linguistic format revealed two findings that had not been found in the overall MANOVA. First, the separate MANOVA showed a main effect of the construction kit on process quality, Wilks' Lambda = .68, $F(5, 251) = 24.12$, $p < .001$. In addition to results that were already found in the overall MANOVA, univariate ANOVA's showed a significant effect on cognitive load, $F(1, 255) = 12.68$, $MSE = 30.29$, $p < .001$, $\eta^2 = .05$. In the group with a construction kit, cognitive load is judged lower ($M = 5.49$, $SD = 1.62$) than in the group without a construction kit ($M = 6.17$, $SD = 1.45$). Second, the separate MANOVA showed an interaction effect of the phenomenarium and construction kit on process quality, Wilks' Lambda = .93, $F(5, 251) = 3.63$, $p < .01$. In addition to the results of figure51_page130.pdf

the overall MANOVA, univariate ANOVA's showed a significant effect on control, $F(1, 255) = 4{,}52$, $MSE = 7.22$, $p <.05$, $\eta^2 = .02$. Figure 5.1b shows the interaction effect on control. If there is no phenomenarium, the absence of the construction kit greatly decreases the experienced control; if there is a phenomenarium, the absence or presence of the construction kit has relatively little effect on perceived control.

Product Quality

The overall MANOVA showed no main effects of the construction kit, phenomenarium or information bank on product quality. However, the separate MANOVA taking into account only data related to the competence figure, revealed an interaction effect of the construction kit and the information bank on product quality, Wilks' Lambda = .97, $F(3, 255) = 2.99$, $p < .05$. Univariate ANOVA's demonstrated that this effect was due to the dependent variables trust, $F(1, 257) = 5.66$, $MSE = 10.82$, $p < .05$, $\eta^2 = .02$, and usability, $F(1, 257) = 4.27$, $MSE = 7.41$, $p < .05$, $\eta^2 = .02$. Figure 5.2a shows the interaction effect on trust. If there is a condensed information bank, the availability of the construction kit greatly enhances perceived trust; but if there is a full information bank, the availability of the construction kit has a reversed effect on trust. Figure 5.2b shows a similar interaction effect on usability.

Learning Effect

The overall univariate ANOVA showed a main effect of the phenomenarium on learning effect, $F(1, 258) = 5.23$, $MSE = 8.43$, $p <.05$, $\eta^2 = .0.20$. In the group with a phenomenarium, learning effect is judged higher ($M = 4.41$, $SD = 1.18$) than in the group without a phenomenarium ($M = 4.05$, $SD = 1.37$). Also, a main effect was found of the construction kit on learning effect, $F(1, 258) = 4.69$, $MSE = 7.55$, $p <.05$, $\eta^2 = .02$. In the group with a construction kit, learning effect is judged higher ($M = 4.40$, $SD = 1.25$) than in the group without a construction kit ($M = 4.06$, $SD = 1.31$). There was no main effect of the information bank and there were no interactions.

5.4 Discussion and conclusion

This study investigated whether a construction kit, phenomenarium, and information bank improve the quality of the process of making a competence map, the quality of the resulting products, and the perceived effects on learning to construct competence maps. In a factorial design, eight conditions with all possible combinations of construction kits (present or absent), phenomenaria (present or absent) and information banks (full or condensed) were compared. Participants used different combinations of supportive aids while they performed three tasks and then rated perceived process and product quality as well as effects on learning.

figure52_page132.pdf

Question 1: Do construction kits, phenomenaria and information banks improve the quality of the process of making competence maps?

The results of our study clearly indicate that the availability of a construction kit enhances the perceived support and control, as expected. Thus, designers who construct—parts of—a competence map with a construction kit experience more help from COMET and know better what to do and how to do it than designers who do not use a construction kit. However, the availability of the construction kit decreases perceived efficiency, indicating that users feel that they spend too much time on the construction of the competence map. This is confirmed by measured time investment: designers who work with the construction kit spend more time constructing the map than designers without the kit. This is not in agreement with our hypothesis. A possible explanation is that the availability of the construction kit raises additional questions about the task, thereby extending rather than reducing the construction process. Another explanation is that it takes additional time to learn how to use the construction kit; a further optimisation of the usability and learnability of the kit might possibly reduce this extra learning time. In addition to the effects on perceived support, control, time investment and efficiency, there were indications that the availability of a construction kit somewhat decreases cognitive load. This supports our presumption that a construction kit frees up processing resources by taking over routine aspects of the task.

With regard to the phenomenarium, the results show that its availability improves perceived support and control as well. This is in line with our expectations. Furthermore, the effect of the availability of a phenomenarium is mediated by the availability of a construction kit. If there is no phenomenarium, the absence of a construction kit greatly decreases experienced support; but if there is a phenomenarium, the absence or presence of a construction kit has relatively little impact on perceived support.

No direct effect was found for the comprehensiveness of the information bank on process quality. This indicates that it does not matter whether a full or a condensed information bank is used for supporting designers in the process of constructing competence maps. This is in contrast to our hypothesis stating that minimal information improves process quality more than full information. Regarding the vast amount of evidence in favour of short texts and minimal information, a possible explanation may be found in the design of this particular study. Perhaps results would have been different if process quality was measured by other, more sensitive variables; as indicated below, it happens that a condensed information bank in combination with a construction kit shows higher perceived *product* quality than a full information bank (in particular, for perceived trust and usability).

Summarizing, a construction kit and a phenomenarium improve the quality of the process of making a competence map, in particular with respect to the process variables support, control and cognitive load. But when designers already have a phenomenarium at their disposal, a construction kit does not significantly enhance perceived process quality. Furthermore, our results indicate that the availability of a construction kit leads to higher time investment and a decrease of perceived efficiency.

Question 2: Do construction kits, phenomenaria and information banks improve product quality?

As indicated above, the availability of a construction kit enhances perceived trust and usability if there is an information bank with condensed information. But if there is a full information bank, the availability of the construction kit has a reversed and smaller effect on trust and usability. Thus, the amount to which designers are pleased with their products and have confidence in them, and the amount to which users think that products can be used for the purpose they have been made for, may be improved by offering them the combination of a condensed information bank and a construction kit. This points to a tendency in favour of the condensed information bank above the full information bank, as hypothesized.

Question 3: Do construction kits, phenomenaria and information banks lead to positive effects on learning to construct competence maps?

Our results clearly indicate a positive effect of the availability of a construction kit and the availability of a phenomenarium on perceived learning about competence maps and their construction. This is in accordance with our expectations, although no effects of the nature of the information bank were found.

Despite the promising results of this study, four remarks are in place. First, all results (except for time investment) pertain to participants' *perceptions* rather than direct measures. Obviously, the findings would be even more convincing when they were corroborated by direct measures. For example, the quality of products such as competence definitions, linguistic formats and competence figures could be measured by independent raters on the basis of a list of criteria, and learning outcomes could be measured by traditional knowledge and skills tests. Whereas it may be difficult to develop hard criteria due to a lack of "reference products" (e.g., there is no generally accepted definition of competence, see Stoof, Martens, van Merriënboer, & Bastiaens, 2002), future research should also include more direct measures of product quality and learning outcomes.

Second, the set up of our study warranted good experimental control but did this at the cost of a high ecological validity. Freshman in the domain of educational sciences worked individually for three hours on an invented task (although this task was as realistic and recognizable as possible). In educational practice, competence maps are typically constructed by heterogeneous teams, consisting of teachers, educational managers and field experts. These teams work on the construction of a competence map for several weeks or even months, in a process that is characterized by negotiation and reaching agreement on several issues (see Stoof, Martens, & van Merriënboer, 2004b; Tilman & Stoof, 2002). Therefore, it would be of great interest to see whether the results of the current study can be replicated by future studies that take place in an ecologically valid setting.

Third, while "the proof of the pudding is in the eating" we did not study the effects of the final competence map, constructed with or without supportive aids, on the design characteristics of a competence-based curriculum. In general, this kind of proof is rare in research on instructional design (Gustafson, 2002). Comparative research is extremely difficult to conduct because the research context (e.g. educational sector), the composition of the project team, and the purpose of the competence map should be similar across experimental groups. Another difficulty is that the effect of a competence map can only be measured after at least one year, after it has actually been used for curriculum design. Despite these difficulties, it is a challenge for future research to collect this kind of conclusive evidence.

A fourth and final remark concerns the way in which the construction kit, phenomenarium and information bank were designed and technically implemented in this study. A lot of effort has been put into the selection and description of the contents and the design of the interface of the three types of supportive aids, for example by having them repeatedly evaluated by domain experts and intended users in advance to the experiment (see Stoof, Martens, & van Merriënboer, 2004b). However, supportive aids can be designed in many different ways. The results of this study are promising with respect to the effects of construction kits and phenomenaria, and to a lesser extent to condensed information banks, but it would be very interesting to evaluate supportive aids designed and implemented in another way than the ones used in this study.

To conclude, we will discuss the practical implications of our study using the format for reporting design principles proposed by van den Akker (1999). In general, a web-based support system may help designers to construct a competence map as a basis for the development of competence-based education, and in particular help them to deal with the conceptual and procedural bottlenecks that are related to this task. The web-based system should at least include a construction kit and a phenomenarium; a possible information bank should include condensed instead of full information. The results of our study indicate that these supportive aids lead to an improvement of perceived process quality, learning effect and—to a lesser degree—product quality. There is one remark with respect to the availability of a construction kit. When a construction kit is present, more time is needed to construct parts of a competence map than when a construction kit is absent. If development time is very limited, one may consider using a web-based support system without a construction kit but with a phenomenarium and a condensed information bank only.

A construction kit should be designed in such a way that it frees up processing resources because it takes over the routine aspects of the task of making a competence map (Norman, 1993). A construction kit should thus direct the users' attention to core aspects of the task and translate the routine aspects into prefabricated processes and parts. Furthermore, it should invite users to actually do things and not bother them with peripheral issues that can be dealt with later. Then, it provokes learning-by-doing and fosters inductive learning. A phenomenarium should contain useful analogies and worked examples. These will typically be based on real-life development processes of project teams that have been constructing competence map (i.e., case studies). Analogies and worked examples enhance task performance and help users to learn about competence maps and their construction because they facilitate the acquisition of cognitive schemas. Guidelines for constructing optimal worked examples can be found in Ward and Sweller (1990), Paas and van Merriënboer (1994) and Sweller, van Merriënboer and Paas (1998). An information bank should contain general information about valuable goals and guidelines for reaching those goals. For example, an information bank on the construction of a competence definition should tell the user what a competence definition looks like and what its main features are. In addition, it should recommend guidelines and heuristics that may be helpful to devise a definition. In general, the amount of information should be kept as small as possible, since results are then best with respect to process quality and learning effect (e.g., Kintsch, 1994).

For all types of supportive aids, including construction kits, phenomenaria and information banks, their design should be based on a thorough analysis of the task of constructing a competence map as well as the knowledge that is necessary for the effective and efficient performance of this task (Stoof, Martens, & van Merriënboer, 2004a). It is strongly recommended to involve task experts in the analysis and design process, and to repeatedly test the supportive aids with real users in a process of rapid prototyping. Our study shows that designers appreciate well-designed web-based support for constructing competence maps and it provides valuable directions for future research that should focus on curriculum effects in ecologically valid educational settings.

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6

The perceived effects of a web-based construction kit on the development of competence maps[6]

Abstract. The development of competence maps that describe final attainment levels of educational programs is a difficult process. The present study examines the effects of a web-based construction kit on quantitative and qualitative measures of perceived process and product quality. Thirteen designers developed an authentic competence map, in two teams with (n = 6) and without (n = 7) the support of the construction kit. The availability of the construction kit improves the perceived process quality. Furthermore, designers seek for other kinds of support if the construction kit is not available: they search the support system more extensively and more often ask experienced team members for help. Design guidelines for construction kits are presented.

[6] This chapter is submitted as: Stoof, A., Martens, R. L., & Van Merriënboer, J. J. G. (2004). *The perceived effects of a web-based construction kit on the development of competence maps*. Manuscript submitted for publication.

6.1 Introduction

In the field of Higher Professional Education, a lot of time and effort is invested in the design of competence-based educational programs. Such programs emphasise the complex skills or professional competencies that students need in their future, professional careers. A so-called competence map is one of the core documents underlying the design of a competence-based program. It describes the final attainment levels in terms of—interrelated—competencies and sub competencies (Schlusmans, Slotman, Nagtegaal, & Kinkhorst, 1999).

Stoof, Martens and van Merriënboer (2004a) report three case studies indicating that teachers and educational managers encounter both conceptual and procedural bottlenecks when they develop competence maps. Conceptual bottlenecks refer to difficulties with defining and demarcating the concept of competence and related terms such as knowledge, skills, expertise, and ability. Procedural bottlenecks refer to difficulties with describing competencies and ordering them into a clear and coherent framework. Both types of bottlenecks have a negative effect on the development process and lead to a sub optimal competence map. This is highly undesirable because a competence map is the major foundation of a competence-based program (de Bie, 2003). If a competence map is of low quality, it is very likely that the developed program will also be of low quality.

The main aim of this study is to investigate if a web-based construction kit has positive effects on the development of a competence-map and the quality of the final product. Perkins (1992) distinguishes different types of computer-based tools and describes a *construction kit* as a tool consisting of prefabricated parts and processes that are specifically designed for executing a particular task. Essentially, a construction kit takes over—routine—aspects of the task, so that the user can focus his or her attention on those task aspects that require reasoning or problem solving. The user is provided with prefabricated decision trees, which provide step-by-step process guidance, and/or prefabricated templates, which provide structure to products. Clear examples of construction kits are the "wizards" included in many Microsoft™ applications and ready-made templates for documents and presentations.

In a previous study, Stoof, Martens and van Merriënboer (2004b) found beneficial effects of the availability of a web-based construction kit on the development of a competence map and the quality of the final product. However, this study lacked ecological validity: participants were educational science students who worked on the development of a competence map, for a hypothetical educational program, for only a couple of hours. The present study focuses on the effects of a construction kit as a supportive aid for the design of a competence map in an ecologically valid context. It is conducted with real-life design teams consisting of teachers, educational managers and field experts who are actually engaged in the transformation of a curriculum from a traditional, knowledge-oriented educational program towards a competence-based program.

The central research questions are: (1) does a construction kit for the development of a competence map improve the quality of the development process, and (2) does it improve the quality of the final product, that is, the competence map itself? With respect to the first research question, we expect that the availability of a construction kit leads to an increase of perceived time efficiency, control over the development process and experienced support, and thus also to a higher level of satisfaction. In addition, we expect a decrease of experienced cognitive load because the construction kit takes over routine aspects of the task, which frees up cognitive capacity. With respect to the second research question, it is likely that the quality of the competence map increases with the quality of its development process. Therefore, it is expected that the availability of a construction kit yields a higher perceived usability of the competence map, its clarity, and trust in its validity.

6.2 Method

The experiment was conducted at the Hogeschool Zuyd, an institute for Higher Professional Education (HPE) in the Netherlands. Amongst other educational programs, the Hogeschool Zuyd provides a two-year program in Social Psychiatric Nursing (SPN). The intention is to end this program and to continue it in another way, for example as a post-HPE program or as a master's program that will be part of a program in Advanced Nursing. In order to legitimise this intention, the need for a revised SPN program as well as its differences with related nursing programs should be made clear. Therefore, the SPN management decided to develop a competence map for the area of SPN in close cooperation with the professional field. In addition to the legitimising aspects, this competence map should also be the basis for a new competence-based SPN curriculum. Initially, the competence map was developed for use at the Hogeschool Zuyd only.

6.2.1 Participants

Participants were four staff members from the SPN department of the Hogeschool Zuyd (2 males, 2 females) and nine field experts in the area of Social Psychiatry (6 males, 3 females). Two groups were formed of six and seven persons. Group composition was kept as balanced as possible with respect to sex, function, expertise, and relative number of SPN staff members and field experts.

6.2.2 Materials

COMET

COMET, which is a loose acronym for Competence Modelling Toolkit, is a web-based support system for developing competence maps (see Figure 4.2; for a thorough description of COMET's design and formative evaluation, see Stoof, Martens, & van Merriënboer, 2004c). The development process consists of six sequential steps: (1) make a competence definition; (2) make a linguistic format; (3) gather data from which competencies will be derived; (4) make competence descriptions; (5) map all competencies into a competence figure, and (6) add general information about the definitions used, the main goal, and the domain of the competence map. An important characteristic of COMET is that the output of each step, including the resulting competence map itself, greatly varies with the needs of the users. They are encouraged to find their own solutions that are useful for their specific situation. This philosophy is based on the fact that there are no generally accepted definitions, frameworks, or procedures with respect to the development of competence maps (Stoof, Martens, & van Merriënboer, 2002).

In order to support the design process, COMET contains a *construction kit* with small tools to support users in going through the six steps. Table 6.1 describes the functionality and output of the tools used in the present study. Note that these tools pertain to only three of the six steps. In addition to a construction kit, COMET includes three other types of support: a *task manager*, which governs the sequence of steps to be taken; a *phenomenarium*, which contains concrete examples of the construction process and resulting products; and an *information bank*, which presents information on the content and goal of each step as well as heuristics that may help to perform it (see Perkins, 1992, for a description of these kinds of tools). Two versions of COMET were used in the current study: one version with the construction kit and one without the construction kit. All other supportive aids were available in both versions and identical to the ones used by Stoof, Martens and van Merriënboer (2004b).

Task instructions

The two teams were asked by their management to develop a competence map for the area of SPN and to use COMET for this purpose. Among other tasks, they had to make a competence definition, a linguistic format, and competence descriptions. A linguistic format is a framework used to describe distinct competencies in a formalized manner. Competence descriptions provide detailed information about each competency that is distinguished in the area of interest and are the basis for the design of a competence-based curriculum.

Table 6.1: Description of tools in the construction kit.

Step	Tool	Functionality	Output
Make a competence definition	Generate a definition	Users are asked to choose between two extremes of six dimensions of competence (levels, context, relationships, elements, output, and type of competencies) and to elaborate on their choices.	The tool generates a partially filled out template for a competence definition.
	Examples of definitions	Five examples of competence definitions are given, reflecting particular choices on the six dimensions.	(no output)
Make a linguistic format	Generate a format	Users are asked to give a yes/no answer to six questions concerning the six dimensions and one question about the inclusion of an example in the format.	The tool generates a linguistic format including an example of its use.
Make competence descriptions	Card sort	An adjusted card sort procedure is described that users can use to analyse the "raw data" (eg, interviews with practitioners).	The procedure results in a list with competency names.

Questionnaire

The questionnaire contained 87 statements measuring process and product quality. *Process quality* was measured by five variables: satisfaction, efficiency, control, support, and cognitive load. Satisfaction is defined as the degree to which users are content with developing the competence map and with working on the subtasks. Statements on satisfaction were adopted from questionnaires described by Deci, Eghrari, Patrik and Leone (1994), and Ryan, Connell and Plant (1990). Efficiency is the degree to which users have the feeling not to spend too much time on tasks. Control is the extent to which users know what to do and how to do it. Support is the amount of help participants experience when they use COMET. Cognitive load is the amount of mental effort needed to perform the task. The cognitive load rating scale was adopted from Paas (1992) and Paas, van Merriënboer and Adam (1994).

The *product quality* was measured by three variables: usability, clarity and trust. Usability is the extent to which users think that products can be used for the purpose they have been made for. Clarity is the extent to which users think that products do not contain ambiguous words or concepts. Trust, finally, is the degree to which users are pleased with their products and have confidence in them. All statements on process quality and product quality concerned both the development of the competence map in general and the three separate tasks for which tools were available in the construction-kit group. For example, the satisfaction statements pertained to making a competence definition, making a linguistic format, making competence descriptions, and the development process in general. An example of a satisfaction statement on the construction of a competence definition is: "I enjoyed making a competence definition."

All statements had to be scored on a 7-point Likert-scale (1 = absolutely not true; 7 = absolutely true), except for the cognitive load statements that had to be scored on a 9-point Likert-scale (1 = very, very low mental effort; 9 = very, very high mental effort). In addition to the statements on process and product quality, the questionnaire contained eight statements on possible confounders: technical problems with using COMET, such as not being able to open certain pages, and the amount of individual participation in each step.

Finally, the questionnaire contained 12 open questions that concerned either the whole development process or the three separate tasks. For example, the three questions on the task of making a competence definition were: (1) "Which part or parts of COMET did you use most often in making a competence definition?"; (2) "Did COMET provide enough support for making a competence definition?", and (3) "How can the support that COMET provides for making a competence definition be improved?" Participants were asked to elaborate on their answers for all questions. The entire questionnaire was stated in Dutch. Table 6.2 gives an overview of the dependent variables, the number of items, and their reliabilities.

Table 6.2: An overview of the dependent measures and their internal consistencies.

		Number of items	Cronbach's α
	Satisfaction	12	.91
	Efficiency	12	.76
Process quality	Control	12	.81
	Support	12	.93
	Cognitive load	4	.83
	Usability [a]	11	.90
Product quality	Clarity	12	.92
	Trust	12	.85

[a] One item was excluded from the Usability-scale to enhance its internal consistency.

6.2.3 Procedure

The experiment was conducted over a period of six weeks. Both groups had a 2-hour weekly meeting and, in addition, the individual team members devoted a maximum of up to four hours per week to the project. Outside the weekly meetings, communication and document exchange took place by regular e-mail and by using Blackboard. After six weeks, both teams had constructed a competence definition, a linguistic format, and competence descriptions. The project leaders of the two groups were asked by the experimenter to ensure that the different parts of the questionnaire were filled out by the team members at predetermined moments. The items and questions on the task of making a competence definition, the task of making a linguistic format, and the task of making competence descriptions had to be filled out just after this particular step was completed by the team. The items and questions on the whole development task were answered at the end of the six-week period. Participants were explicitly asked not to communicate about the development process with team members from the other group. The two versions of COMET (with and without the construction kit) were randomly assigned to the two groups. The participants were unfamiliar with the fact that there were two different versions of COMET.

6.2.4 Analysis

Sum scores were calculated for the process and product quality. Before computing the sum score of process quality, the 9-point cognitive load scale was first reversed (1 indicating highest and 9 indicating lowest cognitive load) and then transformed into a 7-point scale. A median test was performed on both sum scores, as well as on the separate subscales. The qualitative data were screened for comments that provided a deeper understanding of the quantitative findings.

6.3 Results

The response rates were 75% for the group with a construction kit (n = 6) and 79% for the group without a construction kit (n = 7). Table 6.3 shows the medians and ranges for process and product quality. It can be seen from this Table that for all variables the group with the construction kit tends to have higher medians than the group without the construction kit. Note that the increase of cognitive load in the group with a construction kit indicates that participants report a higher cognitive load when a construction kit is present than when it is absent.

A median test on the sum score for *process quality* yielded a significant effect, Me = 197.33, p = .029. As expected, the perceived process quality is higher when the construction kit is present. In addition, median tests were conducted on the separate variables satisfaction, efficiency, control, support, and cognitive load. This yielded a significant effect for perceived control over the development process, which is higher when the construction kit is present, Me = 4.67, p = .029. Median tests on the sum score for *product quality*, and on the separate variables usability, clarity, and trust showed no significant differences between the groups.

Table 6.3: Medians and ranges of the measures in the two conditions.

		Without construction kit $n = 7$			With construction kit $n = 6$		
		Me	*Min*	*Max*	*Me*	*Min*	*Max*
Process quality	Satisfaction	5.56	4.00	6.33	5.92	4.17	6.78
	Efficiency	5.11	4.89	6.00	5.28	4.33	6.18
	Control	4.33	3.83	6.00	5.46	4.33	6.44
	Support	4.67	3.50	6.44	5.42	3.50	6.22
	Cognitive load	5.67	4.50	6.33	6.83	5.00	8.00
Product quality	Usability	5.57	4.33	6.00	6.00	4.22	6.43
	Clarity	4.56	2.89	5.50	5.49	1.22	6.00
	Trust	5.89	5.50	6.67	6.15	4.83	6.33

Note: Scores range from 1 to 7 for all measures except for cognitive load (ranges from 1 to 9).

A qualitative analysis of the answers to the open questions yielded citations that provide a deeper understanding of the perceived benefits of the construction kit, and the disadvantages of its lacking, for the quality of the development process. Several comments illustrate that the group without a construction kit indeed misses something: "I have looked at and read the entire web site for several times. What is the intention? What things do I have to do in which part?" and "The amount of freedom we had was too high. Much time was required to make a start with the notion and definition of what competence is." (Please note that all citations have been translated from Dutch). Similar comments were not made at all by the group that worked with the construction kit.

The qualitative data also indicate that the group without the construction kit adopted two strategies to receive additional support. First, they used more descriptions of steps in COMET than participants in the group with the construction kit. For example, in order to take the step of constructing a competence definition they did not only consult the corresponding description in COMET, but also the description of the next step (i.e., construction of a linguistic format) and even the second next step (i.e., collecting data on competencies). This strategy is useful because all steps in COMET build upon each other. Apparently, consulting information about the subsequent use of a competence definition helped the participants who did not have the construction kit with constructing their competence definition. As one of the participants indicated: "In constructing a definition I have mostly used the part about the linguistic format, because it forces further specification and demarcation." Second, participants in the group without the construction kit regularly consulted more experienced team members. This additional support was designated as "most welcome" and even "necessary". To quote one of the participants: “Without the support and guidance of colleagues who were more familiar with this matter, things would have gone less smoothly.”

Finally, the participants gave interesting suggestions for improving the support provided by COMET. Several participants argued that there is a delicate balance between the amount of available support and the freedom users have to make their own choices. As one participant in the group without the construction kit said: “Too much structure in the support kills the formation of opinions, while too less structure may result in a struggle, especially with non-educationalists.” A similar field of tension was reported by participants in the group with the construction kit as well: “First I thought: I would like to have more examples. But now I think this is not necessary, because too much is already set then.” A similar comment is: “I would like to have more examples. However, this may restrict creativity”.

6.4 Discussion and conclusion

This study investigated whether the availability of a construction kit improves the perceived quality of the process of developing a competence map, as well as the quality of the resulting products. In the same HPE context, two similar groups constructed a competence map for an identical domain and purpose. Only one of the two groups was provided with a construction kit.

Question 1: Does a construction kit improve process quality?

As expected, our results show that the availability of a construction kit improves overall process quality. In particular, the perceived control over the development process increases. Thus, when designers of a competence map are provided with a construction kit, they feel that they better know what to do and how to do it. If a construction kit is lacking, designers seem to compensate for this by using additional ad-hoc strategies for gaining support, such as collecting more information about related development steps and consulting more experienced colleagues in their team. However, the use of those additional strategies does not result in the same level of perceived control as realized by the construction kit. A positive effect of a construction kit on process quality has also been found in a previous study with educational science students (Stoof, Martens, & van Merriënboer, 2004b), providing a strong indication that a web-based construction kit is a very effective aid for the development of competence maps.

Besides this encouraging results, our study points out a negative tendency on cognitive load. When a construction kit is available, participants tend to report a higher perceived cognitive load. This is in contrast to our expectations as well as to the results found in the previous study. A possible explanation may be that cognitive load tends to increase because of the extra effort that is needed to become acquainted with the use of the construction kit. The participants in the present study may have been not as experienced with computer use as the participants in the previous study. This may be a reason for further optimising the construction kit. Another possible explanation may be that the cognitive load in the group with a construction kit tends to be higher not because of the construction kit, but because of other factors. For example, in the present study team members were free to use other materials, information and procedures than provided by COMET, which may further increase the cognitive load. Or, when opinions and interests are very divergent within a project team, this may increase cognitive load as well. These factors do not apply to the previous study since participants worked individually on a competence map in a more controlled setting. It may be concluded that in the present study, cognitive load measures are too broad in that they refer to an entire task, which makes it difficult to explain results.

Question 2: Does a construction kit improve product quality?

The results of the present study show no effect of a construction kit on the quality of developed products. This is not in agreement with our expectations and the results of our previous study. One straightforward explanation for the lack of effects on product quality is the very small sample size. All observed tendencies are in the expected direction, and a larger sample size might have yielded significant differences. However, it is very difficult if not impossible to design a study with both a high ecological validity and a large sample size. A second explanation is that the present study used a full version of an information bank, which described steps and heuristics that may help to perform these steps in an elaborate fashion. The previous study (Stoof, Martens, & van Merriënboer, 2004b) only showed a significant effect on product quality if the construction kit was combined with a *reduced* information bank, which described the steps in a minimal fashion. A final explanation is that the tasks in the present study are not very suitable to reveal effects on product quality. The effects on product quality in the previous study were primarily found for the task of making a competence figure – and this task was not part of the current study.

The findings of this study have to be interpreted with some caution. One obvious limitation is the absence of direct, objective measures. In future research, process quality should also be measured as the amount of time invested in particular steps; the amount of time spent on particular tools; nature and frequency of tool use; and types of group processes, communications, discussions, and conceptual misunderstandings going on in the design team. Product quality should also be measured by expert judgements. Although, the difficulty with such expert judgements is the lack of a clear reference point, that is, there is no generally accepted “good” competence definition or “good” competence map (Stoof, Martens, & van Merriënboer, 2002). Hence, these types of measurements may either start with an exploration of what is generally considered "good", or with the determination of content-free criteria (eg, clarity in language use, use of active verbs, etc.). Finally, it would also be interesting to measure learning outcomes. A positive effect on learning outcomes would indicate that web-based supportive aids couldn't only be used as job aids but also as learning aids.

A second limitation of the present study is that it does not address the effects of developed competence maps on educational program design. Is a competence map generated with a construction kit more useful for developing a competence-based curriculum than a map generated without such a kit? It will be very difficult to answer this question in a proper experimental way, because not a single educational institute will be inclined to invest time, people and money in the development of two different curricula for the same educational program. However, comparative case studies are easier to conduct and may nevertheless provide interesting insights.

To conclude, the present study provides practical guidelines for the optimal design of a web-based construction kit. Basically, it should take over routine aspects of the task of developing a competence map, and so free up capacity for performing the more difficult aspects of the task (Norman, 1993). By doing so, the construction kit provides structure but our qualitative data show that it should provide *some* structure, but not too much. Finding the right balance between structure and freedom is the main issue. If we are successful in that, a well-designed construction kit is a strong aid to support designers with their development of competence maps.

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General discussion

Contents:

7

General discussion

Abstract. The general discussion describes the main conclusions of the work, the implications, the limitations, and provides suggestions for future research. The main conclusion is that the identification and description of competencies as a basis for competence-based education can be effectively supported with a web-based construction kit, phenomenarium and condensed information bank. The implications of the work are described in terms of design guidelines for the optimal development of supportive, web-based aids for designing competence maps. The limitations of the work are discussed, with respect to research focus, design and results. Suggestions for future research concern the specification of the design guidelines; the development of a comprehensive toolkit for the design of high-quality competence-based education; and the development of a tool that supports people in making definitions.

7.1 Main conclusions

The main research problem of this dissertation was: Which tools can support the identification and description of competencies as a basis for competence-based education? A three-step approach to the problem was used, consisting of: (1) explorations about the concept of competence and the bottlenecks within the identification and description of competencies; (2) the development of a valid and practical tool that supports people in competency identification and description; and (3) experimental evaluation of the tool, both within a controlled experimental setting that enabled large group sizes, and an ecologically valid setting with small group sizes. This section summarizes the main conclusions of the three steps and closes with a general conclusion with respect to the main research problem.

7.1.1 Explorations

Chapter 2 focused on the meaning of competence and concluded that there is no generally accepted definition of competence. It was argued that competence definitions should be adequate or *viable* for the specific situation in which they are being used. The viability of a definition increases when it is based on a thorough analysis of the situation. Here, three variables are of interest: the different views on and representations of the concept of competence with the *people* who make the definition; the *goal* of the competence definition; and the broader organizational *context* in which the definition will be used, in particular the people who will use it to develop a competence-based curriculum. Further, the *boundary approach of competence* was presented as a conceptual aid to think about competence. This model consists of two opposing approaches or forces that determine the conceptual boundaries of competence, and hence its meaning. The *inside-out approach* focuses on dimensions of competence, such as teachable versus non-teachable competence, whereas the *outside-in approach* concentrates on the differences between competence and related terms such as knowledge and skills.

A second exploration was discussed in Chapter 3, which focused on the identification of the bottlenecks that people encounter when they are constructing a competence map. Three explorative studies indicated two types of bottlenecks: *conceptual bottlenecks*, that have to do with the unclear meaning of competence and the difference between competence and related terms; and *procedural bottlenecks*, concerning the lack of methods for describing and ordering competencies into a clear framework. Because of these bottlenecks, the development process becomes increasingly complex and inefficient. Team members are insecure about their decisions and about the generated products. This leads to repetitive discussions and to low acceptance for the competence map, because of which the project may even fail. A supportive tool may help people to overcome the bottlenecks and to avoid these undesirable scenarios.

7.1.2 Tool development

The explorations initiated the development of a supportive web-based tool for developing competence maps, and in particular for overcoming the conceptual and procedural bottlenecks as described in the previous section. Chapter 4 described the design and formative evaluation of this tool, which was designated as COMET. The theoretical framework, in which the validity of the tool was grounded, consisted of an analysis of the functionality of the conceptual and procedural support; and an analysis of the supportive aids that can be used for developing the conceptual and procedural support. *Conceptual support* was based on dimensions of competence, that provide guidance to think about the term competence and allow flexibility in choice and personalization of a competence definition. *Procedural support* was adaptive to all kinds of competence definitions and distinguished four steps in describing and ordering competencies: generation of a linguistic format; data collection; data analysis; and ordering competencies in a general framework. Four types of aids were used to design the conceptual and procedural support: a *construction kit*, which consists of prefabricated parts and processes that support decision making and generate products; a *phenomenarium*, which gives examples of processes and products; an *information bank*, which provides explicit textual information about the task at hand; and a *task manager*, which shows which things to do when, sets tasks to be undertaken, guides users in executing the tasks and provides feedback.

Evaluations showed that COMET was practical, except for the subscales *reliability*, measuring the extent to which a competence map can be replicated across time by the same design team; and *attractiveness*, referring to the extent to which users "like" COMET.

7.1.3 Experimental evaluation

The next step was the experimental evaluation of COMET. In particular, the effects of a construction kit, phenomenarium and information bank on process quality, product quality and learning effect were measured. Two studies were conducted: a large-scale study within a controlled setting but with relatively low ecological validity (Chapter 5); and a small-scale study in a less controlled, but ecologically valid context (Chapter 6). Table 7.1 summarizes the quantitative results from both studies.

The first study showed that *process quality* increases when a construction kit is available. In particular, the presence of a construction kit leads to higher perceived support and control, and to lower perceived cognitive load. However, time investment increases and perceived efficiency decreases when a construction kit is available. A possible explanation is that the availability of the construction kit raises additional questions about the task, thereby extending rather than reducing the construction process. Another explanation is that it

Table 7.1. Summary of the quantitative results of the two experiments.

	Process quality	Product quality	Learning effect
		Study 1 (Chapter 5)	
Construction kit	The presence of a construction kit leads to higher perceived support, control, **time investment** and to lower perceived **efficiency** and cognitive load.		The presence of a construction kit leads to an increase of the perceived learning effect.
Phenomenarium	The presence of a phenomenarium leads to higher perceived support and control.		The presence of a phenomenarium leads to an increase of perceived learning effect.
Construction kit * Phenomenarium	If there is no phenomenarium, the absence of a construction kit decreases the perceived support and control. If there is a phenomenarium, the presence or absence of a construction kit has little effect.		
Construction kit * Information bank		If there is a condensed information bank, the presence of a construction kit increases perceived trust and usability. If there is a full information bank, the presence of a construction kit decreases perceived trust and usability.	
		Study 2 (Chapter 6)	
Construction kit	The presence of a construction kit leads to higher perceived control. These is a tendency that the presence of a construction kit leads to higher perceived **cognitive load**.		

Note: Negative findings are represented in Bold.

takes additional time to learn how to use the construction kit. In addition, process quality also increases when a phenomenarium is available. The presence of a phenomenarium leads to higher perceived support and control. Further, if there is no phenomenarium, the absence of a construction kit decreases the perceived support and control. If there is a phenomenarium, the presence or absence of a construction kit has little effect. Furthermore, an interaction effect of the information bank and construction kit on *product quality* was found. If there is a condensed information bank, the presence of a construction kit increases perceived trust and usability. However, if there is a full information bank, the presence of a construction kit greatly decreases the perceived trust and usability. To conclude, results showed that the presence of a construction kit leads to an increase of the perceived *learning effect*. The learning effect also increases when a phenomenarium is available.

The second study showed that the availability of a construction kit improves overall process quality and in particular the perceived control over the development process. The qualitative data showed that if a construction kit is lacking, designers seem to compensate for this by using additional ad-hoc strategies for gaining support, such as searching the support system more extensively and consulting more experienced team members. Besides these encouraging results, the second study points out a negative tendency on cognitive load. When a construction kit is available, participants tend to report a higher perceived cognitive load. This is in contrast to the expectations as well as to the results found in the first study. A possible explanation may be that cognitive load tends to increase because of the extra effort that is needed to become acquainted with the use of the construction kit. The participants have been not as experienced with computer use as the participants in the first study. Another possible explanation may be that the cognitive load in the group with a construction kit tends to be higher not because of the construction kit, but because of other factors. For example, in the present study team members were free to use other materials, information and procedures than provided by COMET, which may further increase their cognitive load. Or, when opinions and interests are very divergent within a project team, this may increase cognitive load as well. These factors do not apply to the first study since participants worked individually on a competence map in a more controlled setting.

7.1.4 General conclusions

When returning to the main research problem, the results showed that the identification and description of competencies as a basis for competence-based education can effectively be supported with web-based tools. In particular, a construction kit, a phenomenarium and to a lesser extent a condensed information bank are beneficial. These aids improve the quality of the process in which a competence map is developed; the learning effect on competence maps and their construction; and to a lesser extent the quality of the products that result from the development process. The main result of the work consists of design guidelines that can be used for the optimal design of supportive, web-based aids for designing competence maps. On a more general level, these design guidelines are useful for developing web-based aids that support complex tasks in general, since the construction of competence maps can be seen as an example of a complex task. The next section describes the implications of the work in terms of design guidelines.

7.2 Implications

The implications of the work are inextricably bound up with the main research problem. The practical nature of this problem logically leads to practical implications, that can be described in terms of design guidelines. Table 7.2 summarizes the design guidelines that can be drawn from the work. It shows that four types of aids can be used for supporting people in identifying and describing competencies: a construction kit, a phenomenarium, an information bank and a task manager (typology after Perkins, 1992). This section describes these aids from four points of view: (1) functionality; (2) design; (3) effect; and (4) restrictions.

7.2.1 Functionality of aids

The functionality of the four aids is closely connected to the conceptual and procedural problems that designers encounter in the development process. Typically, both kinds of support are flexible in that they allow many competence definitions, which is a logical consequence of the fact that there is no generally accepted competence definition. As for *conceptual support*, a construction kit should generate a competence definition by having users take position on several dimensions of competence. A phenomenarium should provide examples of the use of dimensions of competence for defining competence, and should give an example of the resulting definition. An information bank should provide information about dimensions of competence.

As for *procedural support*, a construction kit should help users to generate a linguistic format; provide templates for data collection and analysis; and help users to choose a useful framework. A phenomenarium should provide examples of processes and products with respect to a linguistic format, data collection, data analysis, competence descriptions and a framework. An information bank should generally describe how to generate a linguistic format, how to collect data, how to analyse data and how to choose a useful framework for organizing the competencies. Finally, a task manager guides the user through the steps in which competencies are described and ordered.

Table 7.2. Summary of design guidelines.

	Construction kit	Phenomenarium	Information bank	Task manager
Description	consists of prefabricated parts and processes that support decision making and generate products	gives authentic examples of processes and products	provides explicit textual information about the task at hand	guides the user through the task
Functionality	*Conceptual*: generates a competence definition by using dimensions of competence	*Conceptual*: provides examples of the use of dimensions of competence and the resulting definition	*Conceptual*: gives textual information about dimensions of competence	
	Procedural: generates a linguistic format; provides templates for data collection and analysis; chooses a useful framework for ordering competencies	*Procedural*: gives examples of the process and products with respect to a linguistic format; data collection; data analysis; competence descriptions; competence figure	*Procedural*: describes the goal and method for constructing a linguistic format; collecting and analysing data; choosing a framework	*Procedural*: guides the user through all steps of competency description and ordering
Design	takes over routine aspects of the task and focus the user on core aspects of the task	incorporates useful analogies and worked examples that are based on authentic cases	incorporates general (but restricted!) information about valuable goals and guidelines for reaching those goals	shows which things to do when, sets tasks to be undertaken, guides users in executing the tasks and provides feedback
Effect	beneficial effects on process quality and learning effect	beneficial effects on process quality and learning effect	beneficial effects of condensed information bank in combination with construction kit on product quality	
Restrictions	extra time for task performance may be needed; efficiency may decrease; cognitive load may increase; tension between amount of structure and freedom			

7.2.2 Design of aids

The design of the four aids is based on considerations from cognitive psychology. A construction kit should be designed in such a way that it frees up processing resources because it takes over the routine aspects of the task of making a competence map (Norman, 1993). A construction kit should thus direct the users' attention to core aspects of the task and translate the routine aspects into prefabricated processes and parts. The availability of a construction kit does not primarily support theoretical thinking or considerations at a meta-level, but it rather invites the user to actively work with predefined parts and processes. This provokes learning-by-doing and fosters inductive learning.

A phenomenarium should contain useful analogies and worked examples. These will typically be based on real-life development processes of project teams that have been constructing competence map (i.e., case studies). Analogies and worked examples enhance task performance and help users to learn about competence maps and their construction because they facilitate the acquisition of cognitive schemas. Guidelines for constructing optimal worked examples can be found in Ward and Sweller (1990), Paas and van Merriënboer (1994) and Sweller, van Merriënboer and Paas (1998).

An information bank should contain general information about valuable goals and guidelines for reaching those goals (Anderson, 1985; Reitman, 1964). This information provides the materials for the "early phase" of cognitive skill acquisition, that is, the acquisition of domain knowledge (van Lehn, 1996). In general, the amount of information should be kept as small as possible, since results are then best with respect to task performance (e.g., Kintsch, 1994).

Finally, a task manager should be designed in such a way that is shows which things to do when, by setting tasks to be undertaken, guiding users in executing those steps, and providing feedback on the quality of the process and the product.

7.2.3 Effects of aids

The effects of the construction kit, phenomenarium and information bank have been extensively discussed in section 7.1. In general, the two studies indicate that the task of identifying and describing competencies is most effectively supported with a web-based tool that contains a construction kit, a phenomenarium and a condensed information bank. Both a construction kit and a phenomenarium have beneficial effects on process quality and learning effect; and a reduced information bank combined with a construction kit fosters product quality.

7.2.4 Restrictions on aids

The results of the two experiments also indicate some restrictions for using a construction kit as a supportive aid. When designers use a construction kit, they need additional time for the development process and the perceived efficiency decreases. Also, there are opposing effects of a construction kit on cognitive load. Although this can be explained (see section 7.1.3), it is important to pay attention to this issue in designing a construction kit. Furthermore, there is a delicate balance between the amount of structure that a construction kit provides, and the amount of freedom that users have to develop and apply their own opinions. Hence, a construction kit should provide *some* structure, but not too much. In general, the design of an effective construction kit is difficult and it is therefore recommended to conduct formative evaluations of the effects of a construction kit, in particular on time investment, efficiency, cognitive load and the perceived amount of structure.

7.3 Limitations and future research

This section discusses the limitations of the work within three areas: research focus, design, and deviating results. The suggestions that are provided for future research in these areas aim at a further specification of the design guidelines as discussed in section 7.2. This section also discusses two additional directions for future research: tools for making definitions and the development of a comprehensive toolkit for competence-based education.

7.3.1 Research focus

Limitations that result from the research focus concern five issues: (1) focus on higher education; (2) neglecting collaboration; (3) no study of psychological processes; (4) more extended support than required by the research question; and (5) lack of a singular competence definition.

Focus on higher education

The present work focuses on higher education, although competence-based education is also an issue in primary education, secondary education and technical and vocational training. It may be of great interest to examine to what extent competence-based education in higher education is similar to other educational sectors.

Collaboration

The aspect of collaboration was excluded. This is an important limitation of the research since competence maps are typically made by teams. The reason for excluding this important aspect is that collaboration is a field of study on its own. Its inclusion would have unacceptably extended and complicated the research project. The present work focuses purely on the task of making competence maps, without paying attention to collaboration. Future research may therefore focus on a combination of the supportive aids as discussed in this dissertation and tools for CSCW (Computer Supported Collaborative Work). Such tools may improve group processes in terms of consensus building, focusing, organization of information, decision making, idea generation, and so forth. There are many tools in this area that can be used, such as GroupSystems Cognito®, Groove Workspace®, InTeam®, Meetingworks® and Crealogic®.

Psychological processes.

No measurements were taken of the manner in which the supportive aids were used. It would have been very interesting if data were gathered on how participants use the tools: when, for how long, with which (intermediate) results, in which sequence, with which underlying thinking processes, and so forth. Although fascinating, these questions are not directly related to the practical research problem and therefore they were not part of the present research. However, in future research it may be of great interest to examine whether the assumed psychological processes really take place when using the aids, and even more, what psychological processes exactly take place. Here, verbal protocol analysis may be a useful method for collecting data.

Extended support

The tool that was developed, COMET, did not only support the two problem areas as identified in the bottleneck studies. COMET supported the entire process of making competence maps, including the initiation of the project, the validation of the competence map and its acknowledgement. From an experimental point of view, the inclusion of these phases was not needed. However, from a practical point of view there were some important benefits. In a realistic situation, the development process includes the three phases that were added to COMET. Educational institutes are less eager to cooperate in a research project on making competence maps if the tool only supports one part of the development process. To them, it is of great importance how to go through the initiation phase, in which the project team is composed and the project plan is written; and to validate and acknowledge the competence map.

Dimensions of competence

Instead of using one well-thought, singular definition of competence, dimensions of competence were used. A question that was often put at conferences and presentations was how a tool can support the identification and description of competencies if competence can mean anything. Indeed, for the experiments and for the development of the tool it would have been an enormous simplification if one competence definition was used. In this respect, the use of dimensions may have limited the research project. However, the literature research on the meaning of competence (Chapter 2) made clear that a supportive tool that is based on one particular view on competence would be unacceptable to a lot of people. To put it in other words, the practicality of the tool would be greatly reduced. The solution to this problem is to focus on the question *how* competencies are identified and described, rather than the question *what* should be identified and described.

7.3.2 Design

Limitations to the design concern nine issues: (1) validity of the tool; (2) product evaluations; (3) direct measures of process quality and learning effect; (4) use of aids; (5) expert participants; (6) task manager; (7) conclusive evidence; (8) practicality of the tool; and (9) group sizes, experimental control and ecological validity.

Validity of the tool

The validity of the tool is based on a theoretical framework (Chapter 3). However, because of time constraints the validity of the framework has not been evaluated with domain experts. For example, one of the requirements of validity is that the components of the tool should be consistently linked to each other, which may very well be tested in future research.

Product evaluations

In the present research, the products that were generated – the competence map and intermediate products – were not judged. This happened in the three explorative studies on the identification of bottlenecks (Chapter 3), as well as in the two experimental evaluations (Chapters 5 and 6). Although the experiments did include measures of product quality, the physical products were not taken into account. Future evaluations should take the physical products into account and relate them to process measures. Product quality could be measured by expert judgments. Within the context of competencies, the difficulty with such expert judgments is the lack of a clear reference point, that is, there is no generally accepted “good” competence definition or “good” competence map. Hence, these types of measurements may either start with an exploration of what is generally considered “good”, or with the determination of content-free criteria (e.g., clarity in language use, use of active verbs, etc.). It may be of interest to examine whether beneficial effects of the aids on process quality lead to an improvement of objective product quality as well.

A master’s thesis on this issue (Meeussen, 2004) shows that this may not be the case. Meeussen measured the clarity of the competence definitions that were generated in the first experimental study (Chapter 5), as a measure of product quality. She found that the presence of a full information bank increases definition clarity. Further, she found that when a construction kit is *not* available, definition clarity increases as well. Finally, she found an interaction effect of the phenomenarium and the information bank. If a condensed information bank is available, the presence of a phenomenarium decreases the product clarity. If a full information bank is available, the presence or absence of the phenomenarium has little effect. These results do not corroborate the conclusions of this dissertation. When taking a closer look at the supportive tools, it becomes clear that only the full information bank provides directions for developing a clear competence definition and that the construction kit and phenomenarium mainly focus on simplifying and exemplifying the construction process. Thus, it may be concluded that although a construction kit and a phenomenarium enhance the process quality as well as the learning effect about making definitions, this does not automatically lead to an increase of the *clarity* of competence definitions. Apparently, definition clarity enhances because of other factors. The challenge is to design the supportive aids in such a way that their positive effects on process quality and learning effect are maintained, and that product quality – among which the clarity of competence definitions – increases at the same time.

Direct measures of process quality and learning effect

Both experimental evaluations (Chapters 5 and 6) were based on perceptions of participants rather than direct, objective measures of the process and learning effect (except for time investment). Since the first interest was to examine whether the supportive aids caused any effect at all, measures of perceptions were taken rather than direct measures because perceptions of many topics can easily be measured at the same time. However, it is obvious that the findings need to be replicated in studies that use direct measures. Process quality could be measured as the amount of time invested in particular steps; the amount of time spent on particular tools; the nature and frequency of tool use; and types of group processes, communications, discussions, and conceptual misunderstandings going on in the design team. As for the learning effect, a positive effect on learning outcomes would indicate that web-based supportive aids could not only be used as job aids but also as learning aids.

Use of aids

Neither of the experimental studies tested whether or not participants actually used the aids to perform the tasks. Although the instruction explicitly told the participants to use the aids at hand, it cannot be guaranteed that the participants followed this instruction. There was no control for the actual use of aids because this would require an unacceptably complex design and analysis in the first experiment (Chapter 5), and because it could not be realized within the technical limitations of the second experiment (Chapter 6). Hence, future research should check whether participants actually use the aids they are provided with.

Expert participants

Both experimental studies were conducted with novices in the area of the construction of competence maps. In future research, it may be very interesting to examine whether the effects can be replicated when participants are experts rather than novices.

Task manager

Although the supportive tool included a task manager, its effects were not separately measured. The reason is that in the experimental design, the task manager was used as a basic kind of support that guided participants through the construction process, so that participants would perform the same task and that their results would be comparable. Hence, future research may investigate to what extent the effects of the construction kit, phenomenarium and information bank are mediated by the task manager. Future studies can also directly measure the effects of a task manager on process quality, product quality and learning effect.

Conclusive evidence

The research lacks measures of the effects of the final competence map, constructed with or without supportive aids, on the design characteristics of a competence-based curriculum. For example, is a competence map generated with a construction kit more useful for developing a competence-based curriculum than a map generated without such a kit? In general, this kind of proof is rare in research on instructional design (Gustafson, 2002). Comparative research is very difficult to conduct because the research context (e.g., educational sector), the composition of the project team, and the purpose of the competence map should be similar across experimental groups. It will be very difficult to find an educational institute that is willing to invest time, people and money in the development of two different curricula for the same educational program. Another difficulty is that the effect of a competence map can only be measured after at least one year, after it has actually been used for curriculum design. Despite these difficulties, this kind of conclusive evidence would broaden our understanding of the effects of the aids. In this respect, comparative case studies are easier to conduct and may nevertheless provide interesting insights.

Practicality of the tool

Measures of practicality in the formative evaluations of the tool (Chapter 4) are limited because they are based on a quick review of many of the pages, documents and tools, and only a few of them are explored in depth. Hence, ratings are not “definitive”, since participants may have given other ratings when they would have explored other parts of the tool. Hence, in future research the evaluation of practicality should be designed in such a way that all participants examine the same parts of the aids, with the same effort. Furthermore, an evaluation of the final tool is still needed, so that definitive measures of its practicality are obtained.

Group sizes, experimental control and ecological validity

Research on competency identification and description is characterized by a trade-off between group sizes, experimental control and ecological validity. In educational practice, competence maps are typically constructed by heterogeneous teams, consisting of teachers, curriculum designers, educational managers, branch representatives and field experts. These teams work on the construction of a competence map for several weeks or even months, in a process that is characterized by negotiation and reaching agreement on several issues. Because of these characteristics, ecologically valid studies are almost inevitably conducted with small group sizes and limited experimental control. Experiments with large group sizes and increased experimental control will suffer from a decreased ecological validity. Although these restrictions are hard to avoid, they are still limitations to the work. That is, the three explorative studies (Chapter 3) as well as the second experiment (Chapter 6) were conducted with a limited number of participants and with limited experimental control, and the first experiment (Chapter 5) had low ecological validity. With respect to the effects of a construction kit, the two experiments cover each others' limitations, and therefore the combination of these two studies provides stronger evidence for the benefits of a construction kit. However, measures of the separate effects of a phenomenarium and an information bank were not taken in the second study. Hence, one direction for future research may be to examine the effects of a phenomenarium and an information bank in an ecologically valid context.

7.3.3 Deviating results

Some of the findings are positive or negative exceptions on the main results which limits the impact of the conclusions of the work. The exceptions concern two issues: (1) efficiency, time investment and cognitive load; and (2) meaning of competence.

Efficiency, time investment and cognitive load

In the first experiment (Chapter 5), users feel that they spend too much time on the development of a competence map when they are provided with a construction kit. Similarly, people who work with the construction kit spend more time to develop a competence map than designers without a construction kit. In addition, the second experiment (Chapter 6) indicates that the use of a construction kit increases cognitive load. Thus, although the presence of a construction kit improves process quality, it also seems to decrease efficiency because it requires a higher time investment, and it increases cognitive load.

Although these effects can well be explained (see sections 5.4 and 6.4), the future challenge is to design a construction kit in such a way that the undesirable effects on efficiency, time investment and cognitive load are avoided.

Meaning of competence

Although the meaning of competence has been put forward as a major problem in this dissertation, it was not analysed in which situations the meaning of competence is *not* a problem. From the questionnaire study on the identification of bottlenecks (Chapter 2), we learn that one-third of the participants did not report problems with the meaning of competence. It would be interesting to find out when it is experienced as a problem and when it is not.

7.3.4 Tools for making definitions

An additional direction for future research concerns the problem of defining terms. Competence is not the only term that is hard to define. In education as well as many other areas, crucial terms are used without having a proper or generally agreed definition (e.g., collaborative learning, intelligence, skills). This is a problematical phenomenon, since definitions provide the basis for research and development activities. As for competence, it became clear that the definition issue is a major problem.

Although the aids in COMET proved to have beneficial effects on the construction of a competence definition, it may be valuable to expand the aids in such a way that they will become useful for defining other terms as well. In designing these aids, models from the domain of cognitive psychology and linguistics may be very useful. In these areas, it is well known that word meaning is a fuzzy issue and that definitions are always inaccurate (e.g., Aitchison, 1994). In general, people are well able to use words, but they have much difficulties with defining them. As Aitchison puts it: "the intricate connection between labels people use and their conceptions of the things labelled, is poorly understood." (p. 41).

Two types of models may be used for designing the aids: models about the representation of word meaning in the human mind, and models about the elicitation of word meaning so that it can be used for defining words. *Representation models* are: (1) theories on concepts, which are believed to be the basis of word meaning (see for an overview Hampton, 1997); (2) theories on larger cognitive structures, such as frames (Minsky, 1975), scripts (Schank & Abelson, 1977), schemata (Rumelhart, 1980) and mental models (Johnson-Laird, 1983); and (3) theories on human memory, such as the model of semantic memory (Collins & Quillian, 1969), ACT* (Anderson, 1983), SOAR (Laird, Newell, & Rosenbloom, 1987), and PDP models (Rumelhart & McClelland, 1986). An overview of *elicitation models* can be found in Shadbolt and Burton

(1995) and Tansley and Hayball (1993). Examples of elicitation techniques are concept or card sorting, laddered grids, repertory grids, and matrix generation.

It would be a great challenge to use these models for designing valid, practical and effective tools for defining the words that we use. Besides the practical benefits, such a research project will also yield an important contribution to the theoretical knowledge base on words, word meaning, knowledge representation, and knowledge elicitation.

7.3.5 A comprehensive toolkit for competence-based education

To conclude, future research may also focus on the development of a comprehensive toolkit that can be used for designing competence-based education. Here, two areas of interest are: (1) motivation; and (2) the range of the supported design process.

Motivation

A compelling direction for future research may be to include guidelines from motivational theories in a comprehensive toolkit. In developing competence-based education, the focus is almost entirely on the professional competencies and to a lesser extent on general competencies that can be used for any job, such as learning competencies and career competencies. This also applies to COMET. However, the danger of this unilateral focus is that students may not be sufficiently motivated to learn in the competence-based curriculum. It is a wrong assumption that modern types of education such as competence-based education will automatically lead to increased motivation (Martens, Gulikers, & Bastiaens, in press; Vermetten, Vermunt, & Lodewijks, 2002). A well-designed competence map and competence-based curriculum can only be a real success when students are actually willing to invest effort in the development of competencies. An overview of relevant research on motivation is provided by Ryan and Deci (2000).

Range of design process

The identification and description of competencies is only the first step towards the realization of a competence-based curriculum. Other steps for future research refer for example to the implementation of competence maps in the curriculum, to the development of competence-based learning materials and methods, to the design of competence-based assessments, and to the formal evaluation of competence-based study programs. The ultimate goal is to combine all models and methods into one comprehensive framework or toolkit for developing high-quality competence-based educational programs. Only then, a seamless transition from competence-based education to competencies in the actual working situations and human resource development may be established. Eventually, the desired effect of life-long-learning may really take place.

7.4 A final note

The research described in this dissertation contributes to the area of competence-based education from a practical perspective. Discussions about competencies and competence-based education tend to focus on its linguistic and philosophical aspects, whereas empirical research on practical methods and applications are rare. In designing practical tools, the experience and knowledge within the areas of instructional design and cognitive psychology provide a strong basis. This dissertation tries to prove that this knowledge base can lead to a supportive tool that is practical and effective. There is a lot of interest for this type of tools among educational institutes, since they often do not have the time or ability to develop effective methods on their own. This may be one of the reasons for the phenomenon of "window-dressing", in which an already existing curriculum is simply "flavoured" with competency-expressions without implementing meaningful changes. The increasing attention that educational institutes have been paying to COMET confirms that there is a lot to do for social scientists is this area. Therefore, it is good news that the story about COMET does not end with this dissertation, but that the Open University of the Netherlands as well as the Digital University have plans to develop a training program for the identification and description of competencies by means of COMET. The experiences with this practical application may foster a continuous improvement of this supportive tool and of the design guidelines lying behind.

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Appendix

Contents:

A Examples of aids in COMET

This Appendix provides examples of the four types of aids that were designed and evaluated: a task manager, an information bank, a construction kit and a phenomenarium. Definitions of these aids can be found in section 4.3. Figure A.1 shows the location and appearance of the aids in one step in COMET: the generation of a competence definition.

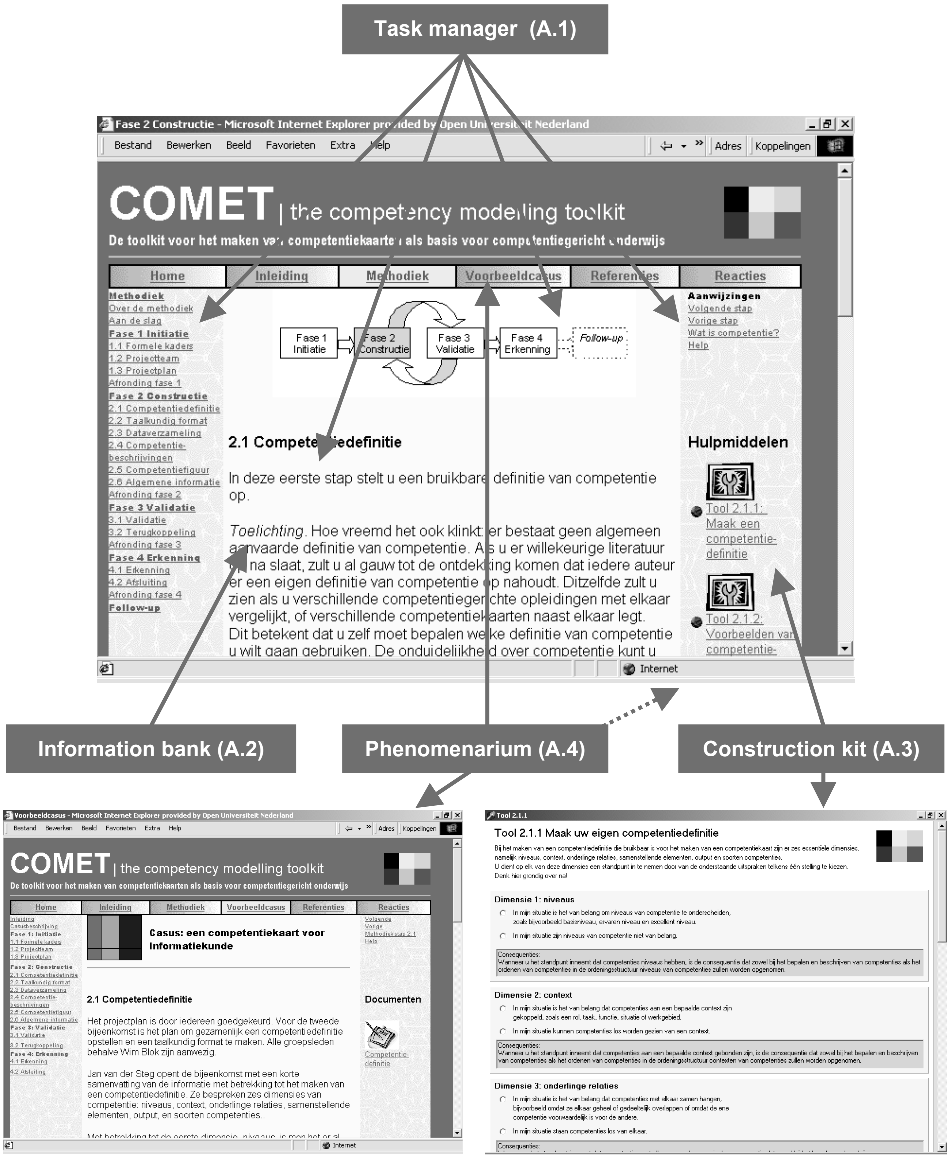

Figure A.1: Location and appearance of aids in one step of COMET. The dotted arrow indicates that the location of the phenomenarium is outside the represented screen capture.

The next sections describe the content of each aid as depicted in Figure A.1. Since the original text in COMET is in Dutch, the text examples are in Dutch as well.

A.1 Task manager

The task manager contains six elements:

1. *Navigation facilities*: enables users to navigate to previous steps, next steps or other steps in the development process (see Figure A.1).
2. *Short task description*: summarizes step in one sentence what happens in a step (see Figure A.1).
3. *Orientation figure*: shows where the user is in the general development cycle (see Figure A.1).
4. *Get-to-work*: tells users specifically who should carry out the task, when to carry out the task and what to use the specific aids for (see Table A.1).
5. *Checklist*: shows what should have been done at the end of a step (see Table A.2).
6. *Help*: provides answers to frequently asked questions (FAQ's) about the website and the method, and contains a glossary of crucial terms (see Table A.3).

Table A.1: Example of a get-to-work section in the task manager: concrete steps in making a competence definition.

Stap 2.1 wordt door het hele projectteam uitgevoerd tijdens een groepsbijeenkomst. Het is efficiënt om tijdens deze zelfde bijeenkomst ook stap 2.2 te nemen in groepsverband. Tool 2.1.1: maak een competentiedefinitie helpt u bij het definiëren van competentie. Gebruik hierbij ook de informatie die hierboven beschreven staat. In tool 2.1.2: voorbeelden van competentiedefinitie kunt u voorbeelden bekijken. Verder kunt u stap 2.1 in de voorbeeldcasus bekijken ter illustratie, of de referenties bij deze stap bestuderen.

Table A.2: Example of a checklist in the task manager : requirements to a competence definition.

Heeft u een bruikbare competentiedefinitie gemaakt?
Is er een verzadiging bereikt in het communicatieproces?
Is het taalgebruik voor iedereen duidelijk en verstaat iedereen er hetzelfde onder?

Table A.3: Part of the Help-function in the task manager: description of the term competence.

Term	*Uitleg*	*Links*
Competentie	Er is geen algemeen geaccepteerde definitie van competentie. In COMET maakt de gebruiker zijn eigen competentiedefinitie, die enerzijds past bij zijn eigen situatie en ideeën, en tegelijkertijd praktische en concrete aanknopingspunten biedt voor het maken van een competentiekaart.	Wat is competentie? Stap 2.1 Competentie-definitie

A.2 Information bank

The information bank can either be full, with extensive texts (see Table A.4) or condensed (see Table A.5).

Table A.4: Full version of one part of the information bank: defining competence.

Hoe vreemd het ook klinkt: er bestaat geen algemeen aanvaarde definitie van competentie. Als u er willekeurige literatuur op na slaat, zult u al gauw tot de ontdekking komen dat iedere auteur er een eigen definitie van competentie op nahoudt. Ditzelfde zult u zien als u verschillende competentiegerichte opleidingen met elkaar vergelijkt, of verschillende competentiekaarten naast elkaar legt.
Dit betekent dat u zelf moet bepalen welke definitie van competentie u wilt gaan gebruiken. De onduidelijkheid over competentie kunt u dus als een kans zien om uw eigen visie over competentie en competentiegericht onderwijs vorm te geven.

Het is belangrijk dat u zich realiseert dat het definiëren van competentie, hoe futiel het ook mag lijken, één van de lastigste problemen is die u in dit project zult tegenkomen. Wanneer u het begrip competentie onzorgvuldig definieert, zal dit in latere fasen leiden tot allerlei problemen, zoals miscommunicatie en problemen bij het bepalen en beschrijven van competenties. Ook zullen er onherroepelijk vragen komen wanneer u de competentiekaart aan derden presenteert.
Tips en valkuilen bij het maken van een competentiedefinitie zijn:

- Het belangrijkste aspect van een competentiedefinitie is dat deze vooral *bruikbaar* moet zijn. Dit betekent dat de competentiedefinitie aanknopingspunten moet bieden voor het maken van een competentiekaart. Een vage competentiedefinitie zal in een latere fase alleen maar verwarring scheppen en het project nodeloos hinderen.
- Een ander belangrijk punt is dat de definitie voor iedereen *duidelijk* moet zijn. Ga er niet vanuit dat iedereen hetzelfde verstaat onder bijvoorbeeld kennis, vaardigheden en vermogens - termen die vaak opduiken in competentiedefinities. Onderschat dit probleem niet! Bij het praten over competentie en aan competentie verwante termen komt veel miscommunicatie voor. Vraag altijd naar wat iemand echt bedoelt. Een manier om duidelijkheid te scheppen is om essentiële termen in de definitie ook weer te definiëren.
- Wees u ervan bewust dat er *geen perfecte competentiedefinitie* bestaat, hoe contra-intuïtief dit misschien ook mag klinken. Het gevaar van een zoektocht naar de ideale definitie is dat u eindeloos in kringetjes blijft ronddwalen. Een competentiedefinitie kan namelijk vanuit veel invalshoeken worden opgesteld, en bij iedere invalshoek horen weer andere vragen. Hak op een gegeven moment de knoop door en ga verder met het project.
- Als u in een latere fase de competentiekaart aan derden presenteert, kunt u erop rekenen dat u vragen krijgt over 'wat nou eigenlijk een competentie is'. Daarom moet u kunnen *beargumenteren* waarom u juist deze definitie gekozen hebt.

In deze stap stelt u dus een 'woordenboekdefinitie' van competentie op. Het gaat hier dus nog niet om het definiëren van de competenties die binnen uw domein relevant zijn, maar puur om het maken van een definitie die duidelijk maakt wat u bedoelt als u het over een competentie heeft. Het beschrijven van de competenties binnen het vakgebied komt in een latere stap.

Table A.5: Condensed version of one part of the information bank: defining competence.

Er bestaat geen algemeen aanvaarde definitie van competentie, waardoor u dus zelf moet bepalen welke definitie van competentie u wilt gebruiken. Het definiëren van competentie is een van de lastigste problemen die u zult tegenkomen in dit project.
Het is van belang dat de definitie bruikbaar moet zijn voor het maken van de competentiekaart. Ook moet de definitie duidelijk zijn voor iedereen. Tenslotte moet u zich realiseren dat een perfecte definitie niet bestaat en dat men aan derden moet kunnen beargumenteren waarom u voor een bepaalde definitie gekozen heeft.

A.3 Construction kit

Table A.6 shows the textual content of one of the tools in the construction kit which helps users to generate a personalized competence definition.

Table A.6: Example of one tool in the construction kit: make a competence definition.

Bij het maken van een competentiedefinitie die bruikbaar is voor het maken van een competentiekaart zijn er zes essentiële dimensies, namelijk niveaus, context, onderlinge relaties, samenstellende elementen, output en soorten competenties.
U dient op elk van deze dimensies een standpunt in te nemen door van de onderstaande uitspraken telkens één stelling te kiezen.
Denk hier grondig over na!

Dimensie 1: niveaus

- In mijn situatie is het van belang om niveaus van competentie te onderscheiden, zoals bijvoorbeeld basisniveau, ervaren niveau en excellent niveau.
- In mijn situatie zijn niveaus van competentie niet van belang.

<u>Consequenties</u>:
Wanneer u het standpunt inneemt dat competenties niveaus hebben, is de consequentie dat zowel bij het bepalen en beschrijven van competenties als het ordenen van competenties in de ordeningsstructuur niveaus van competenties zullen worden opgenomen.

Dimensie 2: context

- In mijn situatie is het van belang dat competenties aan een bepaalde context zijn gekoppeld, zoals een rol, taak functie, situatie of werkgebied.
- In mijn situatie kunnen competenties los worden gezien van een context.

<u>Consequenties</u>:
Wanneer u het standpunt inneemt dat competenties aan een bepaalde context gebonden zijn, is de consequentie dat zowel bij het bepalen en beschrijven van competenties als het ordenen van competenties in de ordeningsstructuur contexten van competenties zullen worden opgenomen.

Dimensie 3: onderlinge relaties

- In mijn situatie is het van belang dat competenties met elkaar samen hangen, bijvoorbeeld omdat ze elkaar geheel of gedeeltelijk overlappen of omdat de ene competentie voorwaardelijk is voor de andere.
- In mijn situatie staan competenties los van elkaar.

<u>Consequenties</u>:
Wanneer u het standpunt inneemt dat competenties met elkaar samenhangen, is de consequentie dat zowel bij het bepalen en beschrijven van competenties als het ordenen van competenties in de ordeningsstructuur de relaties tussen competenties zullen worden opgenomen.

Table A.6 (cont.)

Dimensie 4: samenstellende elementen

- o In mijn situatie is het van belang dat competenties uit deelelementen bestaan, zoals bijvoorbeeld kennis, vaardigheden, attituden, meta-cognitie, persoonseigenschappen, inzichten en talenten.
- o In mijn situatie zijn competenties ondeelbaar.

<u>Consequenties</u>:
Wanneer u het standpunt inneemt dat competenties uit deelelementen bestaan, is de consequentie dat bij het bepalen en beschrijven van competenties deelelementen van competenties willen worden opgenomen.

Dimensies 5: output

- o In mijn situatie is het van belang dat competenties leiden tot een bepaalde output, zoals bijvoorbeeld kwaliteit van gedrag, een product of dienst of een ander zichtbaar resultaat.
- o In mijn situatie zijn competenties niet gekoppeld aan een bepaalde output.

<u>Consequenties</u>:
Wanneer u het standpunt inneemt dat competenties tot een bepaalde output leiden, is de consequentie dat bij het bepalen en beschrijven van competenties de output van competenties zal worden opgenomen.

Dimensies 6: soorten competenties

- o In mijn situatie zijn niet alleen beroepscompetenties van belang, maar ook bijvoorbeeld beroepsoverstijgende competenties, leercompetenties en loopbaancompetenties.
- o In mijn situatie zijn alleen beroepscompetenties van belang.

<u>Consequenties</u>:
Wanneer u het standpunt inneemt dat ook andere competenties dan beroepscompetenties van belang zijn, is de consequentie dat bij het bepalen van competenties ook andere soorten competenties dan beroepscompetenties zullen worden opgenomen.

Note. The Table only shows the textual contents of this particular tool in the construction kit. However, the tool is designed as an "intelligent" tool. After the user has made his or her choices on the six dimensions of competence, the tool automatically generates an overview of the "ingredients" that should be incorporated in the competence definition. It also provides clues how to personalize the definition so that it fits to the specific situation of the user.

A.4 Phenomenarium

The phenomenarium contains product examples (see Table A.7) as well as process examples (see Table A.8).

Table A.7: Product example of one part of the phenomenarium: a competence definition.

"Een competentie is een cluster van kennis, vaardigheden en attituden, die gekoppeld is aan een taak en leidt tot een bepaald resultaat. Een competentie kan betrekking hebben op zowel beroepsspecifieke competenties als beroepsoverstijgende competenties, en leer- en loopbaancompetenties."

Table A.8: Process example of one part of the phenomenarium: the generation of a competence definition by a project team.

Het projectplan is door iedereen goedgekeurd. Voor de tweede bijeenkomst is het plan om gezamenlijk een competentiedefinitie opstellen en een taalkundig format te maken. Alle groepsleden behalve Wim Blok zijn aanwezig.
Jan van der Steg opent de bijeenkomst met een korte samenvatting van de informatie met betrekking tot het maken van een competentiedefinitie. Ze bespreken zes dimensies van competentie: niveaus, context, onderlinge relaties, samenstellende elementen, output, en soorten competenties.
Met betrekking tot de eerste dimensie, *niveaus*, is men het er al snel over eens dat het voor de opleiding niet zoveel zin heeft om meerdere niveaus van competentie te definiëren. Studenten moeten aan het einde van de opleiding over de gewenste competenties beschikken en zullen deze daarna verder ontwikkelen in een werksituatie. Deze 'hogere' niveaus van competentie zijn voor de opleiding echter niet van belang en hoeven dus ook niet te worden gedefinieerd.
Ook de tweede dimensie, *context*, leidt snel tot een uitkomst. Men is het erover eens dat een competentie inderdaad aan een bepaalde context gebonden is. Voor wat betreft het type context kiest men voor taken. Johan de Wit is het hier niet helemaal mee eens; hij zou liever voor rollen willen kiezen.
De derde dimensie, *onderlinge relaties*, heeft als uitkomst dat competenties niet aan elkaar gerelateerd zijn. Men heeft wel het gevoel dat competenties inderdaad samenhangen, maar hoe precies kan men niet goed benoemen. Daarom besluit men om hierin de makkelijkste weg te bewandelen.
De vierde dimensie, *samenstellende elementen*, leidt tot heftige discussies. Men is het erover eens dat juist deze dimensie aangeeft 'wat een competentie precies is'. Men vraagt zich af wat er nu anders is aan competentie in vergelijking met bijvoorbeeld vaardigheden. Johan de Wit komt met literatuur op de proppen en noemt zes verschillende competentiedefinities. Wim Blok noemt nog een andere competentiedefinitie die ze gebruiken in het bedrijf waar hij werkzaam is. Dirk Rooi schudt regelmatig zijn hoofd en vraagt zich af waarom alles niet bij het oude kan blijven: gewoon kennis, vaardigheden en houdingen, dat is tenminste duidelijk. Soms wordt er een voorstel gedaan voor samenstellende elementen, maar er lijkt maar geen consensus over te kunnen komen.
Jan van der Steg besluit in te grijpen en stelt het volgende standpunt voor: competentie bestaat uit een cluster van samenstellende elementen, zonder deze samenstellende elementen verder te benoemen en competentie zodoende te beschouwen als een soort van 'Black Box'. Er lijkt wat draagvlak voor deze oplossing te zijn, maar dan zegt Dirk dat een competentie dan wel heel vaag wordt. De anderen zijn het hier eigenlijk wel mee eens, en uiteindelijk besluit men daarom toch maar om een competentie te definiëren als zijnde een cluster van kennis, vaardigheden en attituden, bij gebrek aan een betere omschrijving. Johan vraagt nog wel af wat er dan 'nieuw' is aan de competentiedefinitie. Annelies antwoordt dat de definitie niet alleen maar de samenstellende elementen bevat maar ook aan andere dimensies en dus andere informatie gekoppeld is.Voor wat betreft de vijfde dimensie, *output*, is het weer eenvoudiger. De groep besluit dat competentie inderdaad aan een bepaalde output gekoppeld is. Men benoemt deze output als 'resultaat'.
De laatste dimensie, *soorten competenties*, doet de discussie weer oplaaien. Johan de Wit is heel duidelijk vóór het bestaan van meerdere soorten competenties naast alleen beroepsspecifieke competenties. Hij beargumenteert dat juist dit zo 'nieuw' is aan het competentiedenken. Dirk Rooi is het hier helemaal niet mee eens, want die 'andere' competenties leer je vanzelf wel op de werkplek of überhaupt in het dagelijks leven. Het is niet de taak van de opleiding om aan studenten dergelijke 'basiscompetenties' te leren.
Hier laat Ingrid Janssen, alumna Informatiekunde, zich horen. Zij geeft aan dat zij juist die 'extra' competenties gemist heeft in de opleiding. Ze noemt wat voorbeelden van situaties waar ze tegenaan is gelopen, en uiteindelijk besluit men om ook beroepsoverstijgende competenties, leercompetenties en loopbaancompetenties in de definitie op te nemen.
Johan spreekt met de groep af dat hij op basis van de gemaakte keuzes een competentiedefinitie zal opstellen en deze naar iedereen toe zal mailen.

Summary

The main research problem of this dissertation is: Which tools can support the identification and description of competencies as a basis for competence-based education? Chapter 1 describes the background of the problem within the broader context of competence-based education. Presently, there is a lot of attention for competence-based education in many countries. Competence-based education is characterized by a focus on authentic tasks; authentic assessment; and integration of learning contents instead of fragmentation. These characteristics are believed to prepare students for professions that have become increasingly complex, dynamic and knowledge intensive. The research problem is a result from the lack of supportive tools for designing competence-based education.

Chapter 1 also introduces the term *competence map*, which describes final attainment levels in terms of competencies. A competence map results from the process of competency identification and description.

Further, the chapter presents a three-step approach to the problem, consisting of: (1) explorations about the concept of competence and the bottlenecks with the identification and description of competencies; (2) development of a valid and practical tool that supports people in identifying and describing competencies; and (3) experimental evaluation of the tool.

The explorations are discussed in Chapters 2 and 3. Chapter 2 focuses on the meaning of competence and concludes that there is no generally accepted definition of competence. It argues that competence definitions should be adequate or *viable* for the specific situation in which they are being used. The viability of a definition increases when it is based on a thorough analysis of the situation. Here, three variables are of interest: the different views on and representations of the concept of competence with the *people* who make the definition; the *goal* of the competence definition; and the broader organizational *context* in which the definition will be used, in particular the people who will use it to develop a competence-based curriculum.

Further, the *boundary approach of competence* is presented as a conceptual aid to think about competence. This model consists of two opposing approaches or forces that determine the conceptual boundaries of competence, and hence its meaning. The *inside-out approach* focuses on dimensions of competence, such as teachable versus non-teachable competence, whereas the *outside-in approach* concentrates on the differences between competence and related terms such as knowledge and skills.

A second exploration is discussed in Chapter 3, which describes three studies on the identification of the bottlenecks that people encounter when they

are constructing a competence map. The first study is a questionnaire study among 15 persons with experience in making competence maps. The two other studies are case studies of teams of nine and four persons respectively that were constructing a competence map as a basis for curriculum innovations. An observation form and a questionnaire were used to collect data in the case studies. In all studies, data collection was based on a framework that describes four problem areas as encountered in literature: conceptual, procedural, interpersonal and organizational. The three studies indicate two types of bottlenecks: *conceptual bottlenecks*, that have to do with the unclear meaning of competence and the difference between competence and related terms; and *procedural bottlenecks*, concerning the lack of methods for describing and ordering competencies into a clear framework. The chapter proposes solutions to these bottlenecks in terms of instructional design tools.

Tool development is discussed in Chapter 4. The explorations initiated the development of a supportive web-based tool for developing competence maps, and in particular for overcoming the conceptual and procedural bottlenecks. The chapter describes the design and formative evaluation of this tool. It begins with a description of the theoretical framework, in which the validity of the tool is grounded. This framework consists of an analysis of the functionality of the conceptual and procedural support; and an analysis of the supportive aids that can be used for developing the conceptual and procedural support. *Conceptual support* is based on dimensions of competence, that provide guidance to think about the term competence and allow flexibility in choice and personalization of a competence definition. *Procedural support* is adaptive to all kinds of competence definitions and distinguishes four steps in describing and ordering competencies: generation of a linguistic format; data collection; data analysis; and ordering competencies into a general framework.

Four types of aids were used to design the conceptual and procedural support: a *construction kit*, which consists of prefabricated parts and processes that support decision making and generate products; a *phenomenarium*, which gives examples of processes and products; an *information bank*, which provides explicit textual information about the task at hand; and a *task manager*, which shows which things to do when, sets tasks to be undertaken, guides users in executing the tasks and provides feedback.

The tool, COMET (which is a loose acronym for Competency Modelling Toolkit) was developed by means of *evolutionary prototyping*. Four prototypes were developed and evaluated by means of questionnaires, heuristic evaluations, interviews, walkthroughs and focus groups. Participants were the intended users (both experts and novices), domain experts, internet users and web designers. Measures of design, appeal, goal, content, confidence and relevance show that COMET is practical, except for the subscales *reliability*, measuring the extent to which a competence map can be replicated across time by the same design team; and *attractiveness*, referring to the extent to which users "like" COMET. The chapter also provides an extensive description of COMET from three perspectives: the user, the curriculum developer, and the instructional designer.

The experimental evaluation of the tool is discussed in Chapters 5 and 6. The effects of a construction kit, phenomenarium and information bank on process quality, product quality and learning effect were measured. Two studies were conducted: a large-scale study within a controlled context with low ecological validity; and a small-scale study in a less controlled context but with high ecological validity.

Chapter 5 describes the first study. Here, 266 Educational Science students constructed several parts of a competence map, individually, within 135 minutes. In a factorial design, each of the participants was provided with one of the eight versions of COMET, containing a task manager, construction kit (presents / absent), phenomenarium (present / absent) and an information bank (full / condensed). Data were gathered by means of a 96-item questionnaire.

Results show that *process quality* increases when a construction kit is available. In particular, the presence of a construction kit leads to higher perceived support and control, and to lower perceived cognitive load. Negative findings are that time investment increases and perceived efficiency decreases when a construction kit is available. Further, the presence of a phenomenarium leads to higher perceived support and control. An interaction effect reveals that if there is no phenomenarium, the absence of a construction kit decreases the perceived support and control. If there is a phenomenarium, the presence or absence of a construction kit has little effect.

Also, an interaction effect of the information bank and construction kit on *product quality* is found. If there is a condensed information bank, the presence of a construction kit increases perceived trust and usability. However, if there is a full information bank, the presence of a construction kit greatly decreases the perceived trust and usability.

To conclude, results show that the presence of a construction kit leads to an increase of the perceived *learning effect*. Learning effect also increases when a phenomenarium is available.

The second study is described in Chapter 6. Here, two teams of six and seven persons respectively constructed an authentic competence map as a basis for curriculum innovations. The team members were staff members of the educational institution of interest and field experts. Both teams operated within the same context and were heading for the same goal. They were supported by a task manager, phenomenarium, and information bank. Additionally, one team was provided with a construction kit whereas the other team was not. Data were gathered by means of a questionnaire that was largely similar to the one used in the first study, with additionally 12 open questions on the experienced support.

Results show that the availability of a construction kit improves overall process quality and in particular the perceived control over the development process. The qualitative data show that if a construction kit is lacking, designers seem to compensate for this by using additional ad-hoc strategies for gaining support, such as searching the support system more extensively and consulting more experienced team members.

The dissertation concludes with Chapter 7, which is the general discussion. It describes the main conclusions of the work, the implications, the limitations and future research, and concludes with some final notes.

The main *conclusion* is that the identification and description of competencies as a basis for competence-based education can be effectively supported with a web-based construction kit, phenomenarium and condensed information bank.

The *implications* of the work are described in terms of design guidelines for the optimal development of supportive, web-based aids for designing competence maps or complex tasks in general. The design guidelines describe the functionality, design, effects and restrictions of a construction kit, phenomenarium, information bank and task manager. From a broader perspective, the design guidelines are also useful for designing web-based support for complex tasks in general and for the identification and description of curriculum content in general.

The *limitations* of the work are discussed within three areas: research focus, design, and deviating results. The suggestions that are provided for *future research* in these areas aim at a further specification of the design guidelines. Two additional directions for future research are discussed: tools for making definitions and the development of a comprehensive toolkit for competence-based education.

To conclude, the *final notes* state that this dissertation pays an important contribution to competence-based education because of its practical focus. The attention that educational institutes have been paying to COMET proves that there is a need for practical, supportive tools.

Dutch summary / Nederlandse samenvatting

De centrale onderzoeksvraag in dit proefschrift luidt: Met welke gereedschappen of *tools* kan het identificeren en beschrijven van competenties als basis voor competentiegericht onderwijs worden ondersteund? In hoofdstuk 1 wordt de achtergrond van deze onderzoeksvraag beschreven vanuit de context van competentiegericht onderwijs. Er is op dit moment veel aandacht voor competentiegericht onderwijs in binnen- en buitenland. Competentiegericht onderwijs wordt onder andere gekenmerkt door een focus op authentieke taken, authentieke toetsing en integratie van leerinhouden in plaats van fragmentatie. Hierdoor zou het onderwijs beter aan moeten sluiten bij de grote veranderingen die plaatsvinden in de maatschappij. Vooral beroepen zijn complexer, dynamischer en kennisintensiever geworden. De onderzoeksvraag komt voort uit het feit dat er weinig tools zijn die het ontwikkelen van competentiegericht onderwijs ondersteunen.

In hoofdstuk 1 wordt ook de term *competentiekaart* geïntroduceerd. Dit is een gestructureerd overzicht van competenties die studenten tijdens een bepaalde opleiding dienen te verwerven, ter vervanging van de klassieke eindtermen. De competentiekaart is het resultaat van het proces waarin competenties worden geïdentificeerd en beschreven.

In het hoofdstuk wordt tevens de aanpak beschreven die gevolgd is voor het beantwoorden van de onderzoeksvraag. Deze aanpak bestaat uit drie stappen: (1) het verkennen van de term competentie en het in kaart brengen van de knelpunten die optreden bij het maken van een competentiekaart; (2) het ontwikkelen van een valide en praktisch bruikbare tool voor het maken van een competentiekaart; en (3) het experimenteel evalueren van de tool.

Het eerste deel van het proefschrift omvat de verkenningen, die worden beschreven in hoofdstuk 2 en 3. Hoofdstuk 2 gaat over de betekenis van de term competentie. De conclusie is dat er geen algemeen aanvaarde definitie van competentie bestaat. In het hoofdstuk wordt beargumenteerd dat een competentiedefinitie vooral *viable* moet zijn, wat zoveel betekent als: de levensvatbaarheid van de definitie in de situatie waarin hij wordt gebruikt. De levensvatbaarheid van een definitie neemt toe als de definitie gebaseerd is op een analyse van de situatie. Hierbij spelen drie variabelen een rol: de *mensen* die de definitie maken en de verschillende opvattingen die zij hebben over competenties; het *doel* van de definitie; en de *context* waarin de definitie wordt gebruikt en door wie.

Het grootste gedeelte van het hoofdstuk gaat over de zogenaamde *boundary approach of competence*. Dit is een conceptueel hulpmiddel om na te denken over de betekenis van de term competentie. Het model bestaat uit twee tegenovergestelde krachten die op elkaar inwerken en de grenzen van competentie bepalen: de *boundary*. De eerste kracht duwt van binnenuit tegen de boundary en omvat dimensies van competentie, zoals de dimensie leerbaar – niet leerbaar. De tweede kracht duwt van buitenaf tegen de boundary en drukt de verschillen uit tussen competentie en gerelateerde termen zoals kennis en vaardigheden. De keuzes die mensen maken ten aanzien van de dimensies en gerelateerde termen bepalen de vorm van de boundary en daarmee ook de specifieke betekenisgeving van het begrip competentie.

In hoofdstuk 3 worden drie verkennende onderzoeken besproken die als doel hebben de knelpunten te onderzoeken die mensen tegenkomen wanneer ze een competentiekaart maken. Het eerste onderzoek is een vragenlijstenonderzoek onder 15 mensen die ervaring hebben met het maken van competentiekaarten. De twee andere studies zijn case-studies van respectievelijk een team van negen en een team van vier personen die een competentiekaart construeerden als basis voor onderwijsvernieuwing. Hierbij werd gebruik gemaakt van een observatieschema en een vragenlijst. In alledrie de studies was de dataverzameling gebaseerd op een viertal probleemgebieden die in de literatuur werden genoemd: conceptuele problemen, procedurele problemen, interpersoonlijke problemen en problemen met betrekking tot de organisatie. De resultaten tonen aan dat er twee belangrijke knelpunten zijn: *conceptuele knelpunten*, die betrekking hebben op de betekenis van competentie en de verschillen tussen competentie en gerelateerde termen; en *procedurele knelpunten*, waarbij vooral het gebrek aan methoden voor het beschrijven en overzichtelijk ordenen van competenties een probleem is. Hoofdstuk 3 wordt afgesloten met een aantal oplossingen voor deze knelpunten die zijn geformuleerd in termen van *instructional design tools*.

Het tweede deel van het proefschrift betreft de ontwikkeling van de tool. In hoofdstuk 4 wordt beschreven hoe een valide en praktisch bruikbare tool die mensen ondersteuning biedt bij het oplossen van de conceptuele en procedurele knelpunten tot stand is gekomen. Het eerste deel van het hoofdstuk gaat over het theoretische raamwerk dat de basis voor de validiteit van de tool vormt. Hierin staat enerzijds de functionaliteit van conceptuele en procedurele ondersteuning centraal en anderzijds de manier waarop de ondersteuning kan worden vormgegeven. *Conceptuele ondersteuning* is gebaseerd op dimensies van competentie, die aan de ene kant handvaten bieden om over de term competentie na te denken en aan de andere kant de flexibiliteit bieden waardoor mensen hun eigen persoonlijke definitie kunnen maken. *Procedurele ondersteuning* is bruikbaar voor allerlei soorten competentiedefinities en bestaat uit vier stappen waarin competenties worden beschreven en geordend: het ontwikkelen van een taalkundig format, het verzamelen van data, het analyseren van data en het ordenen van competenties in een overzichtelijk model.

De conceptuele en procedurele ondersteuning is vormgegeven met behulp van vier soorten webgebaseerde hulpmiddelen. Het eerste hulpmiddel is de *construction kit*. Deze bestaat uit voorgefabriceerde onderdelen en processen die beslisvorming ondersteunen en (delen van) producten genereren. Het tweede hulpmiddel is het *phenomenarium*, dat authentieke voorbeelden bevat van zowel het proces waarin een competentiekaart wordt gemaakt als van de resulterende (tussen)producten. Het derde hulpmiddel, de *information bank*, bestaat uit tekstuele informatie over de doelen van de taak en een algemene beschrijving van de procedures die moeten worden gevolgd. Het vierde hulpmiddel is de *task manager*, die de gebruiker door alle stappen heen leidt en feedback geeft.

De tool, COMET (Competency Modelling Toolkit), is ontwikkeld met behulp van de *evolutionairy prototyping* benadering. Bij de ontwikkeling van COMET zijn in totaal vier prototypes ontwikkeld en getest bij de doelgroep (zowel beginnelingen als experts in het maken van competentiekaarten), domein experts, internetgebruikers en ontwerpers van websites. De methoden en instrumenten die hierbij werden gebruikt waren vragenlijsten, heuristic evalations, interviews, walkthroughs en focus groups. Evaluaties laten zien dat COMET een praktisch bruikbare tool is, vooral met betrekking tot de vormgeving, het doel en de doelgroep, het vertrouwen in de tool en de relevantie. Uitzonderingen zijn dat de proefpersonen de betrouwbaarheid van de methodiek laag inschatten en dat ze de website niet zo aantrekkelijk vinden. In het laatste deel van het hoofdstuk wordt COMET uitgebreid beschreven vanuit drie perspectieven: die van de gebruiker, de curriculumontwikkelaar en de instructie-ontwerper.

Het derde deel van het proefschrift, experimentele evaluatie, wordt beschreven in hoofdstuk 5 en 6. In de evaluatie wordt bekeken wat de effecten van een construction kit, een phenomenarium en een information bank zijn op de kwaliteit van het proces waarin een competentiekaart wordt gemaakt, op de kwaliteit van de resulterende producten en het leereffect op het gebied van competentiekaarten en hoe deze worden gemaakt. Er zijn twee experimenten uitgevoerd: een grootschalig experiment in een gecontroleerde, maar ecologisch minder valide context, en een kleinschalig experiment in een minder gecontroleerde, maar ecologisch valide context.

Het eerste experiment wordt beschreven in hoofdstuk 5. Aan dit onderzoek deden 266 eerstejaarsstudenten Pedagogische Wetenschappen mee. Gedurende maximaal 135 minuten ontwikkelden zij individueel onderdelen van een competentiekaart. Hierbij werden zij ondersteund door één van de acht versies van COMET, bestaande uit een task manager, een construction kit (aanwezig / afwezig), een phenomenarium (aanwezig / afwezig) en een information bank (volledig / gereduceerd). De gegevens werden verzameld met behulp van een vragenlijst die uit 96 gesloten items bestond.

De resultaten van de analyses laten zien dat *proceskwaliteit* toeneemt als er een construction kit is. Meer specifiek, de aanwezigheid van een construction kit leidt tot een toename van de gepercipieerde ondersteuning en controle en tot een afname van gepercipieerde cognitive load. Er zijn echter ook twee negatieve bevindingen: als er een construction kit is neemt de tijdsinvestering toe en de gepercipieerde efficiëntie af. De proceskwaliteit (en meer in het bijzonder de gepercipieerde ondersteuning en controle) neemt ook toe als er een phenomenarium aanwezig is. Een interactie-effect laat zien dat als er geen phenomenarium is, de afwezigheid van een construction kit ervoor zorgt dat de gepercipieerde ondersteuning en controle afnemen. Daarentegen, als er wel een phenomenarium is, maakt het niet veel uit of er een construction kit aanwezig is of niet.

Met betrekking tot de *productkwaliteit* is er een interactie-effect van de information bank en construction kit. Als er een gereduceerde information bank is (dat wil zeggen, met zeer summiere tekstuele informatie), leidt de aanwezigheid van een construction kit tot een toename van het gepercipieerde vertrouwen in het product en de gepercipieerde bruikbaarheid. Als er een volledige information bank is, zorgt de aanwezigheid van een construction kit voor een drastische daling van gepercipieerd vertrouwen en bruikbaarheid.

Het *leereffect* tenslotte neemt toe als er een construction kit aanwezig is en ook als er een phenomenarium aanwezig is.

Het tweede experiment wordt beschreven in hoofdstuk 6. In dit onderzoek werkten twee teams van respectievelijk zes en zeven personen aan de ontwikkeling van een authentieke competentiekaart als basis voor onderwijsinnovatie. De teams bestonden uit stafleden van de onderwijsinstelling en externe experts. Beide teams werkten in dezelfde context en hadden hetzelfde doel. Ze werden ondersteund door een task manager, phenomenarium en een (volledige) information bank. Eén team werd daarbij aanvullend ondersteund door een construction kit, maar het andere team niet. Ook in dit onderzoek werden de gegevens verzameld met behulp van een vragenlijst. Deze was in grote lijnen hetzelfde als die in het eerste experiment. Aan de vragenlijst waren nog 12 open vragen over de ervaren ondersteuning toegevoegd.

De resultaten van het tweede experiment tonen opnieuw aan dat de aanwezigheid van een construction kit tot een hogere proceskwaliteit leidt, en in het bijzonder tot een hogere mate van gepercipieerde ondersteuning. De kwalitatieve gegevens laten zien dat ontwikkelaars van een competentiekaart die niet door een construction kit worden ondersteund hiervoor compensatie zoeken. Ze passen dan ad-hoc strategiën toe waarin ze bijvoorbeeld bij meer ervaren collega's en teamgenoten te rade gaan of waarin ze de ondersteunende tool in zijn geheel intensiever bekijken, op zoek naar aanvullende ondersteuning.

Het proefschrift wordt afgesloten met hoofdstuk 7: de algemene discussie. Deze bestaat uit vier onderdelen: de conclusies, de implicaties, de beperkingen en suggesties voor vervolgonderzoek en tenslotte enige afsluitende opmerkingen.

De belangrijkste *conclusie* van het gehele onderzoek is dat de identificatie en beschrijving van competenties als basis voor competentiegericht onderwijs effectief kan worden ondersteund met een webgebaseerde construction kit, phenomenarium en gereduceerde information bank.

De *implicaties* van het werk worden beschreven in termen van ontwerprichtlijnen. Deze beschrijven op welke manier ondersteunende tools voor het maken van een competentiekaart zouden moeten worden vormgegeven. De ontwerprichtlijnen omvatten informatie over de functionaliteit, het ontwerp, de effecten en de beperkingen van een construction kit, phenomenarium, information bank en task manager. Vanuit een breder perspectief zijn de ontwerprichtlijnen bruikbaar voor het ontwikkelen van webgebaseerde ondersteuning voor complexe taken in zijn algemeen en voor het bepalen en beschrijven van onderwijsinhoud in zijn algemeen, ongeacht of de term competentie een rol speelt of niet.

De *beperkingen* van het onderzoek zijn onderverdeeld in drie groepen: beperkingen die zijn voortgekomen uit de focus van het onderzoek, beperkingen ten aanzien van de opzet en uitvoering van het onderzoek en beperkingen als gevolg van afwijkende resultaten. De suggesties voor *vervolgonderzoek* die uit deze beperkingen voortvloeien hebben als doel de ontwerprichtlijnen nader te specificeren. Twee andere richtingen voor vervolgonderzoek zijn het ontwerpen van tools die mensen ondersteuning bieden bij het definiëren van termen en de ontwikkeling van een generiek model voor het ontwikkelen van competentiegericht onderwijs.

Het hoofdstuk wordt beëindigd met een aantal *afsluitende opmerkingen*. Een centrale opmerking is dat dit proefschrift een belangrijke bijdrage levert aan competentiegericht onderwijs vanwege de praktische focus. De interesse die door onderwijsinstellingen tijdens het onderzoek voor COMET getoond is maakt duidelijk dat er een grote behoefte is aan praktisch bruikbare tools.

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Curriculum vitae

Angela Stoof was born on the 21st of February, 1974, in Rotterdam, the Netherlands. In 1991 she finished secondary education at the Gertrudislyceum in Roosendaal. From 1991 until 1995 she studied Information Sciences at the Hogeschool Midden-Brabant in Tilburg. She completed this study program with a thesis on a market research for a multimedia course that was developed by the Open University of the Netherlands. From 1995 until 1999 she studied Cognitive Psychology at the Maastricht University. Her thesis concerned matching processes between characteristics of job-seekers and courses and training programs provided by the Centrum voor Werk en Inkomen (CWI) in Maastricht. After her graduation she returned to the Open University of the Netherlands. Here, at the Educational Technology Expertise Center (OTEC) she worked from July 1999 until September 2004 on a PhD-project on tools for the identification and description of competencies.